CITY OF MEMPHIS – STANDARD CONSTRUCTION SPECIFICATIONS
SECTION 02890 TRAFFIC SIGNALS

PART 1 - SCOPE

This work shall consist of furnishing and installing all necessary materials and equipment to complete in place traffic signal systems and/or to modify existing traffic signal systems. The work includes earthwork and concrete placement for pole foundations, installation of conduit with required earthwork, erection of signal support poles and span wires or mast arms, installation of signal heads and a controller for each signal system, and installation of all wiring, appurtenances, and auxiliary equipment necessary for the complete installation of the traffic signal system as shown on the Plans or Design Standards and as specified herein or as directed by the Owner.

PART 2 - MATERIALS AND EQUIPMENT

2.01 GENERAL REQUIREMENTS.

All material shall be new unless otherwise indicated in the Plans or specified in the Specifications or other Contract Documents. The signals, controllers, and appurtenances shall be located as shown on the Plans or as directed by the Owner. All incidental parts which are not shown on the Plans or specified herein or in other Contract Documents and which are necessary to complete the traffic signals or other electrical systems or required for modifying existing systems, shall be furnished and installed as though such parts were shown on the Plans or specified herein. Costs of such incidentals shall be included in bid prices for other items. All systems shall be complete and in operation to the satisfaction of the Owner at the time of completion of the work.

A. Regulations and Codes.

All electrical equipment and materials shall conform to the Standards of the Nation Electrical Manufacturer's Association (NEMA) or the Radio Manufacturer's Association, whichever is applicable. In addition to the requirements of the Specifications, the Plans, and other Contract Documents, all material and work shall conform to the requirements of the National Electrical Code (NEC); the Standards of the American Society for Testing Materials (ASTM); the American National Standards Institute – National Electrical Safety Code (ANSI C-2); the American Standards Association (ASA); U.S. Department of Transportation, Tennessee Department of Transportation Manual on Uniform Traffic Control Devices (MUTCD); Institute of Transportation Engineers (ITE); International Municipal Signal Association, Inc. (IMSA); and any other City of Memphis ordinance which may apply.

B. Materials.

1. All materials furnished shall conform to the requirements provided herein, the Plans, Design Standards, and where applicable the appropriate sections of the City of Memphis Standard Construction Specifications or other Contract Documents.

2. If the Contractor proposes to furnish materials or supplies other than those specified, he shall furnish complete descriptive data, including performance capabilities, specifications, and other such data as the Owner determines necessary to evaluate the substitute items. The Owner may accept or reject any substitution which is requested according to these Specifications. The provisions of this substitution of materials shall not relieve the Contractor of the responsibility of meeting the requirements of the Plans and Specifications. All materials must be approved before any installation will be permitted.

3. Throughout the entire project, all units of any one pay item shall be of the same manufacture and model unless otherwise approved by the Owner.

2.02 TRAFFIC CONROL EQUIPMENT AND MATERIALS.

A. Signal Heads.

Vehicle and pedestrian signals complete with mounting devices as shown on the Plans and Design Standards shall be provided by the Contractor. Each signal face shall consist of one or more signal sections, each containing an optical unit, lens, main housing, door and visor and designed and constructed so as to fit rigidly and securely together, one above the other to present a clean

appearance and provide a weather-tight enclosure for the optical and electrical equipment. These signal heads shall meet the requirements of the latest ITE Standards for "Adjustable Face Vehicle Traffic Control Signal Heads, " and the NEC where applicable. Each signal head assembly shall be supplied complete with a traffic signal illuminating device of the required size and ready for operation with the connection of field wiring.

1. Materials.

   a. The housing and door of each signal section shall be fabricated from corrosion resistant U.V. stabilized Polycarbonate resin material. The moldings shall be a minimum of 0.090 inches thick and be ribbed for additional strength at point of high stress. Additional thickness shall be provided as necessary to eliminate light transmission through the housing, door, visor, or backplate.

   b. Visors and backplates shall be fabricated from corrosion resistant U.V. stabilized Polycarbonate resin material. Visors shall a 0.100 inch minimum thickness. Backplates shall have a 0.125 inch minimum thickness.

2. Construction.

   a. Housing.
   The housing of each section shall be a one-piece, corrosion resistant, Polycarbonate resin molding with integral sides, top, and bottom and free of voids, cracks, inclusions, or blow holes. Each vehicle signal shall be furnished with provisions for mounting of a backplate. The top and bottom of the housing shall have an opening 2 inches in diameter to accommodate standard 1 ½ inch pipe, with no other opening in the top or bottom of the housing. Individual signal sections shall be fastened together, one above the other into a complete signal face, by means of plated nuts, bolts, and washer in such a manner than any section may be rotated about a vertical axis and positioned at an angle with respect to an adjacent section. The opening hub shall have 72 circumferential serrations to secure each section in its orientation, adjustable in 5 degree increments, and prevent its inadvertent rotation. A six position labeled barrier terminal block shall be provided in each signal face for the purpose of field connections. The barrier terminal shall be installed in the circular yellow or yellow arrow section of each signal face. If the face has neither of these sections, the terminal block shall be installed in the uppermost section of the head. There shall be provisions for the attachment of a ¼ inch tether line to the bottom of each span wire mounted signal head as shown in the Design Standards. A pinnacle shall be provided to close all 2 inch openings in each housing which will not otherwise be sealed from the weather when installed with the specified mounting hardware.

   b. Door.
   The housing door of each signal section shall be a one-piece, corrosion resistant Polycarbonate resin molding free of voids, cracks, inclusions, or blow holes. The outer face of the door shall have four (4) holes equally spaced about the circumference of the lens opening to accommodate the secure mounting of the signal head visor. Two stainless steel hinge pins shall attach the door to the housing, one in the upper left corner and one in the lower left corner of the door. Two stainless steel wing nuts or screws, one in the upper right corner and one in the lower right corner of the door, shall be used for opening the door and closing it tight against the housing. The wing screws or nuts shall be installed to prevent their accidental removal or falling out. The removal of the hinge pins and the operation of the wing nuts or screws shall not require the use of tools.

3. Optical System.

   a. The optical system shall consist of a lens, reflector, and lamp socket. The system shall be designed to minimize sun phantom and eliminate light spillover. Prefocused,

incandescent lamps shall be the light source for all signals. The signals shall be designed for 116 watt lamps with 2-7/16 inches LCL in 8 inch signals and 150 watt lamps with 3 inch LCL in 12 inch signals. All vehicle signal lenses shall be Polycarbonate resin or acrylic and shall conform to the latest standards of the ITE and ASA optical specification. All reflectors shall be of ALZAK aluminum construction. The lamp socket shall be of bakelite construction. Lamp replacement shall be accomplished without the use of tool or the removal of the lens or reflector. The socket shall be fixed-focus and permit its rotation a full 360 degrees to any position to orient bulb filament openings. The socket shall be securely held in the reflector so as not to loosen, rotate, or fall out under vibration of traffic and wind movement of the signal head. The lamp socket shall be provided with two coded #18 AWG copper wire leads. The leads shall be fitted with insulated spade wire terminals and be of sufficient length to make field connections at the barrier terminal block.

b. The vehicular and pedestrian signal lens, signal lamp socket, and reflector shall form a sealed module with molded neoprene gaskets holding the seal to prevent moisture, dust, and road film contamination from entering the optical module and the signal housing.

4. Lamps.

Each signal section shall be supplied with a clear traffic signal lamp. Eight inch vehicle signals shall be supplied with a 67 watt, 125 volt, medium brass base, A21, 2-7/16 inch light center length (L.C.L.) lamp, rated life of 8,000 hours. Twelve inch vehicle and pedestrian signals shall be supplied with a 116 watt, medium brass base, A21, 3 inch light center length lamp, rated life of 8,000 hours. All lamps supplied shall otherwise conform to the Institute of Transportation Engineers (ITE) “Standard for Traffic Signal Lamps.”

5. Visors.

Each signal door shall be fitted with a corrosion resistant Polycarbonate resin tunnel visor. Eight inch signals shall have visors a minimum of 7 inches long; 12 inch signals shall have visors a minimum of 9-1/2 inches long. The visor shall be flat black inside and outside. The visors shall be securely attached to the door at four locations equally spaced about the circumference of the lens opening with four plated screws or four bayonet type self-locking locking tabs integrally formed with the visor. The visor shall fit flush against the door, and no light shall leak between the door and the visor. The visor shall be preformed into a fixed cylindrical shape of the proper diameter to be installed around the lens.

6. Backplate.

Each vehicle signal head assembly, so required by the Plans, shall be equipped with a backplate with a minimum width of 5 inches with rounded corners. Stainless steel screws shall be provided for mounting to the signal housing. The backplate shall consist of one or more pieces fabricated from corrosion resistant, flat Polycarbonate resin material colored flat black on the front and back.

7. Legends.

a. Pedestrian heads shall be fitted with lenses that, when illuminated, shall provide a Portland Orange “Don’t Walk” in the top section and a Lunar White “Walk” in the bottom section, all conforming to the ITE Standard for “Adjustable Face Pedestrian Signal Heads.” The remainder of the lens shall be black and opaque. When not illuminated, the legends shall not be distinguishable.

b. Traffic signal lenses shall be circular; red, yellow, or green in color; and 8 inch or 12 inch nominal diameter; as specified. No legend shall be permitted. Arrow lenses shall be circular, 12 inches in diameter, green or yellow in color, and opaque except for the arrow legend. If and arrow lens is only applicable for one orientation (i.e., left, straight, or right), this information shall be indicated in a permanent and appropriate manner on the lens without impairing the optical properties of the lens.

8. Mounting Hardware.

a. Spanwire suspension fitting with cable entrance shall be a one-piece malleable iron casting, minimum wall thickness 3/16 inch, and free of flash and voids. The cable entrance shall have a plastic bushing with a minimum inside diameter of 1-1/4 inches. The suspension fitting shall provide six separate, clevis pin positions for balancing the signal assembly. The thickness of the solid casting in this suspension area shall be a minimum of 5/8 inch. A hex head threaded malleable iron lock nipple shall be provided for attaching the signal head to the bottom of the suspension fitting for one-face signals or to the top bracket of multi-face signal brackets.

b. The mounting hardware for each signal face shall include a nylon, serrated, 72 tooth lock ring with full locking pins and a circular neoprene gasket for weather sealing.

c. All openings in signal heads and bracketry which are not otherwise utilized for signal mounting shall be closed with a hex ornamental pinnacle assembly complete with circular neoprene gasket and malleable iron hex lock nut. No conduit lock nuts are permitted.

d. The Spanwire Suspension Clamp Assembly, where required, shall consist of a galvanized, malleable iron Spanwire clevis saddle, 5/8 inch diameter plated steel clevis pin with cotter key, two ½ inch plated steel “U” bolts with nuts and washers (no “J” bolts are permitted), and a galvanized malleable iron cable locking bar, all fitted for 5/16 inch guy span. Galvanizing shall conform to ASTM A 153.

e. The Balance Adjustor required for each Spanwire suspended signal head shall be supplied with a malleable iron balance adjustor complete with steel I-bolt and steel clevis pin with cotter key to be installed between the spanwire suspension clamp and the suspension fitting with cable entrance.

f. Brackets, where required shall consist of a malleable iron center outlet body, schedule 40 pipe, elbows, serrated fittings, and other hardware as required to provide a multi-face signal head assembly with internal wiring raceways to each face as specified.

g. The Spanwire Bottom Bracket, where required, shall consist of a metal brace, a neoprene washer, and shall attach to a ¼ inch tether wire at the bottom of the bracket. The point of attachment to the tether wire attachment shall extend 1 inch beyond the standard backplate to allow the signal head to be tethered at any angle without interfering with the backplate. The security bolts for this tether wire attachment shall be furnished with locknuts. The spanwire bottom bracket shall attach to the bottom of the signal head using the pinnacle hole and a neoprene washer and have 72 circumferential serrations to secure the bracket to the signal head and shall be adjustable in 5 degree increments. The bracket is to fasten to the signal head using a malleable iron hex locknut or a bolted clamp. An attachment fitting for ¼ inch tether wire shall be mounted at the center of the bracket as shown in the Design Standards.

h. The Polycarbonate Side of Pole Bracket, where required, shall be one-piece molding with internal wiring raceway for banding or lag screw attachment to steel or wood poles. Brackets shall be designed to withstand 100 mph wind loading on it and the signal head. Each bracket shall have an integrally molded 72 tooth serrated ring for signal head positioning and come complete with 1 ½ inch nipple, hex lock nut, pinnacle, neoprene washer, and one ¼ inch interlocking shim for plumbing signals.

i. The Elevator Plumbizer, where required, shall be malleable iron or bronze allow for mast arm installations, with internal wire raceway, sized to fit a 1 ½ inch tenon, complete with three set screws and one through bolt with nuts and lock washer, complete with serrations to lock signal sections.

j. The Slip Fitter Collar, where required, for top post mounting shall be malleable iron, including one vertical 1 ½ inch nipple with hex lock nut; two 1 ½ inch threaded horizontal entrances; and three set screws for attachment to the post. All horizontal entrances not used for attaching signal brackets shall be closed with pinnacle and neoprene washer.

9. Color, Finish, and Painting.

a. Polycarbonate resin hardware shall have color impregnated throughout the material. The finish shall be smooth and unflawed. Signal head parts shall be colored as follows:

(1) Vehicle Head:

Housing	–	Federal Yellow
Door	-	Flat Black
Tunnel Visor	-	Flat Black inside and out
Backplate	-	Flat Black front and back
Pole Bracket	-	Federal Yellow

(2) Pedestrian Head:

Housing	-	Federal Yellow
Door	-	Black
Tunnel Visor	-	Flat Black inside and out
Pole Bracket	-	Federal Yellow

b. All metal hardware, except those specified as galvanized, plated, or stainless steel shall be painted Federal Yellow. The metal parts shall be painted with a primer coat and a finish coat of oven baked enamel meeting the requirements of Paragraph 2.03.B of this Specification Section. Lenses, reflectors, gaskets, and polycarbonate parts shall not be painted.

B. TRAFFIC SIGNAL CONTROLLERS.

1. General.

a. Description.
The controller shall consist of an electrically operated traffic control device, which shall function continuously and unattended at the at the locations shown in the Plans, to assign vehicle and pedestrian right-of-way by illuminating signals in accordance with the prescribed timing program. The signal display shall conform with the sequence charts and the phase diagrams included on the Plans.

b. NEMA Standards.
The controller and associated equipment shall, as a minimum, comply with the latest edition of NEMA Standard No. TS 1 “Traffic Control Systems” (hereinafter referred to as NEMA); and that Standard is hereby made a part of this Specification. All requirements, functions, operational modes, and features required by this specification, which are not required by NEMA, shall be incorporated in such a manner as to retain compliance with the NEMA. Where a conflict should arise between the NEMA and this Specification, this Specification shall prevail.

c. Components.
The traffic control assembly, referred to as the controller, shall include the timer (control unit), load relay switches, signal conflict monitor, line filters and necessary auxiliary equipment mounted in a cabinet. The controller shall be installed at the location shown on the Plans or as directed by the Owner. Each controller shall be wired complete with the specified auxiliary equipment and ready for operation by making field connection to the signal display

equipment, detectors, and electric service line.

d. Documentation.

(1) The Contractor shall provide detailed technical circuit description and circuit schematic information applicable to the operations and maintenance of the controller and associated auxiliary equipment. Cabinet wiring diagrams with interconnection details, schematics, and maintenance techniques shall be furnished. Information in manual form shall include a materials guide which shall contain the replacement part numbers and description of all components used. All solid-state devices shall be listed by their generic number or in lieu of this, a complete cross-index from manufacturer's numbers to generic number shall be provided and shall be identified on all printed circuit boards or other mounting locations. Parts lists shall be itemized with the respective chassis, module, or circuit wherein parts may be found. A total listing of parts without grouping will not be acceptable. Schematic circuit drawings shall be furnished that are slow to fade when exposed to sunlight over long periods of time. A developed and fixed printing process, or one of the forms of printing by actual ink transfer, will be acceptable. Blueline prints and sepias are not acceptable.

(2) Two (2) copies of all the above information shall be provided with each controller unit for the controller and piece of auxiliary equipment in the cabinet. In addition, three (3) copies of a cabinet wiring diagram, including all auxiliary equipment, shall be supplied with each controller unit. A clear, resealable plastic envelope shall be attached with screws to the inside of each cabinet door for storage of the cabinet wiring prints. This envelope shall be mounted so as to avoid restriction of the circulation of air into and out of the cabinet.

e. Solid State Construction.

All controllers shall employ high quality, solid-state modular electronic construction designed for continuous unattended operation. No camshafts, rotary stepping line switches, lighting discharge tubes, or vacuum or gaseous tubes, shall be used for internal or external auxiliary circuitry, except incandescent or gaseous tube indicator lamps are acceptable devices.

f. Training.

The Contractor shall provide (with manufacturer personnel), as part of the contract of the signals, a minimum of twenty-four (24) hours of classroom and laboratory instruction for three (3) City of Memphis technicians on the operation and maintenance of each separate type of controller supplied. Instructions shall be on a highly technical level, describing the design and operation of electronic circuitry in detail as well as demonstrating troubleshooting and repair techniques. The rudiments of dial systems and basic solid-state theory are below the level of the instruction required by this Specification. This instruction shall begin when requested by the Owner, following the contract award. The Owner may require that this training be conducted at facilities provided by the Contractor. The Contractor shall provide round trip transportation from Memphis to the school site and suitable lodging during the school if the school is held away from Memphis.

g. City of Memphis Controller Identification by Type:

Type 2A: Two phase semiactuated solid-state, digitally timed with pedestrian timing for both phases, and dual side street maximum.

Type 2B: Two phase, fully actuated solid state, digitally timed with pedestrian timing for both phases, and dual maximum for each phase.

Type 3A: Three phase fully actuated, solid state digitally timed with pedestrian timing for the artery and the cross street phases, and dual maximum for each phase. An advance

or leading protected left turn phase is the identifying characteristic of this type.

Type 3T: Three phase, fully actuated, solid state, digitally timed with pedestrian timing for artery and cross street phases, dual maximum for each phase. A trailing or lagging protected left turn phase is the identifying characteristic of this type.

Type 4: Four phase, fully actuated, solid state, digitally timed with pedestrian timing for the artery and the cross street phases, and dual maximum for each phase. The identifying characteristic is a protected left turn phase on one approach of both the artery and the cross street.

Type 5: Five phase, fully actuated, solid state, digitally timed with pedestrian timing and volume density for two artery and two cross street phases, and dual maximum for each of two left turn phases. The identifying characteristic is a protected left turn phase on both artery approaches, with any phase capable of concurrent but independent timing with another nonconflicting phase.

Type 6: Six phase fully actuated solid state, digitally timed with pedestrian timing and volume density for two artery and two cross street phases, and dual maximum for each of three left turn phases. The identifying characteristic is a protected left turn phase on one cross street approach and a protected left turn on both artery approaches with any phase capable of concurrent but independent timing with another nonconflicting phase.

Type 8: Eight phase fully actuated, solid state, digitally timed with pedestrian timing and pedestrian timing and volume density for two artery and two cross street phases, and dual maximum for each of four left turn phases. The identifying characteristic is a protected left turn phase on both artery approaches and both cross street approaches, with any phase capable of concurrent but independent timing with another nonconflicting phase.

RR (Suffix): Any type controller with the suffix “RR” added shall be supplied with the necessary circuitry to provide railroad preemption of the normal signal operation as described in Paragraph 2.02.B.4.d of this Specification and required on the sequence chart made a part of this Specification.

2. Cabinet.

Cabinets shall be provided for each controller installed by the Contractor. The cabinet installed by the Contractor shall be equipped with a radio interference filter installed at the electric service line input. The filter shall provide a minimum electrical noise attenuation of 50 decibels over the range of 200 kilohertz to 75 megahertz.

a. Surge Protection.

The controller assembly shall conform to requirements of the latest edition of NEMA TS 1, Part 2 – “Environmental Standards and Test Procedures.” No cabinet surge protection or line filters shall be considered in providing the required transient protection of NEMA Part 2 (Reference note of NEMA TS 1-1976 Part 2, Page 6, Figure 2-2). Each 120 VAC electromechanical relay in the cabinet, flash transfer, signal monitor, etc., shall be suppressed with a 150 volt, 20 amp Varistor installed across it to ground. The AC+ service line cabinet terminal shall be suppressed with a 150 volt, 20 amp Varistor installed across it to ground. Each AC+ signal display field terminal shall have a 150 volt, 20 amp Varistor installed across it to ground. Each pedestrian detector input field terminal shall have a 36 volt ziner diode installed across it to ground.

b. Pin Connectors.

Electrical connections between the control unit and the cabinet wiring harness(es) shall be accomplished using one or more “MS” type multiple pin connectors at the controller (NEMA

type) and insulated spade wire terminal connectors at the cabinet terminal blocks. The pin connectors and function pin assignments shall be in accordance with Tables 02890-1, 02890-2, and 02890-3. All functions developed within the control unit for existing or future expanded phasing, up to the maximum capability of the controller, shall be available at the cabinet terminals for greatest operational flexibility. All functions and pin assignments required by NEMA shall be provided as a minimum. Additional functions and features, either required by these specifications or offered by the manufacturer, shall be provided through the pin connector on otherwise spare positions.

TABLE 02890 – 1
CONNECTOR A

Alphabetical Listing of Pin Assignments

Pin	Function	Pin	Function
A	Spare 1	f	Phase 1 Vehicle Call Det
B	+24V DC External	g	Phase 1 Ped Call Det
C	Voltage Monitor Output	h	Phase 1 Hold
D	Phase 1 Red Driver	i	Force Off Ring 1
E	Phase 1 Don't Walk Driver	j	Ext Min Recall All Phases
F	Phase 2 Red Driver	k	Manual Control Enable
G	Phase 2 Don't Walk	m	Call to Nonactuated I
H	Phase 2 Ped Clear	n	Test Input A
J	Phase 2 Walk	p	AC+
K	Phase 2 Vehicle Call Det	q	Spare 3
L	Phase 2 Ped Call Det	r	Coded Status Bit B Ring 1
M	Phase 2 Hold	s	Phase 1 Green
N	Stop Timing Ring 1	t	Phase 1 Walk
P	Inhibit Max Term Ring 1	u	Phase 1 Check
R	External Start	v	Phase 2 Ped Omit
S	Interval Advance	w	Omit All Red Clear Ring 1
T	Spare 2	x	Red Rest Mode Ring 1
U	AC-	y	Spare 4
V	Chassis Ground	z	Call to Nonactuated II
W	Logic Ground	AA	Test Input B
X	Flashing Logic Output	BB	Walk Rest Modifier
Y	Coded Status Bit C Ring 1	CC	Coded Status Bit A Ring
Z	Phase 1 Yellow	DD	Phase 1 On
a	Phase 1 Ped Clear	EE	Phase 1 Ped Omit
b	Phase 2 Yellow	FF	Ped Recycle Ring 1
c	Phase 2 Green	GG	Max 2 Selection – Ring 1
d	Phase 2 Check	HH	Spare 5
e	Phase 2 On		

TABLE 02890 – 2
CONNECTOR B

Alphabetical Listing of Pin Assignments

Pin	Function	Pin	Function
A	Phase 1 Next	f	Phase 4 Next
B	Spare 1	g	Phase 4 Omit

Pin	Function
C	Phase 2 Next
D	Phase 3 Green Driver
E	Phase 3 Yellow Driver
F	Phase 3 Red Driver
h	Phase 4 Hold
i	Phase 3 Hold
j	Phase 3 Ped Omit
k	Phase 6 Ped Omit

TABLE 02890 – 2 (cont'd)
CONNECTOR B

Pin	Function
G	Phase 4 Red Driver
H	Phase 4 Ped Clear Driver
J	Phase 4 Don't Walk Driver
K	Phase 4 Check
L	Phase 4 Veh Call Det
M	Phase 4 Ped Call Det
N	Phase 3 Veh Call Det
P	Phase 3 Ped Call Det
R	Phase 3 Omit
S	Phase 2 Omit
T	Phase 5 Ped Omit
U	Phase 1 Omit
V	Ped Recycle Ring 2
W	Spare 2
X	Spare 3
Y	Phase 3 Walk Driver
Z	Phase 3 Ped Clear Driver
a	Phase 3 Don't Walk Driver
b	Phase 4 Green Driver
c	Phase 4 Yellow Driver
d	Phase 4 Walk Driver
e	Phase 4 On
m	Phase 7 Ped Omit
n	Phase 8 Ped Omit
p	Overlap A Yellow Driver
q	Overlap A Red Driver
r	Phase 3 Check
s	Phase 3 On
t	Phase 3 Next
u	Overlap D Red Driver
v	Spare 4
w	Overlap D Green Driver
x	Phase 4 Ped Omit
y	Spare 5
z	Max 2 Selection – Ring 2
AA	Overlap A Green Driver
BB	Overlap B Yellow Driver
CC	Overlap B Red Driver
DD	Overlap C Red Driver
EE	Overlap D Yellow Driver
FF	Overlap C Green Driver
GG	Overlap B Green Driver
HH	Overlap C Yellow Driver

TABLE 02890 – 3
CONNECTOR C

Alphabetical Listing of Pin Assignments

Pin	Function
A	Coded Status Bit A Ring 2
B	Coded Status Bit B Ring 2
C	Phase 8 Don't Walk Driver
D	Phase 8 red Driver
E	Phase 7 Yellow Driver
F	Phase 7 Red Driver
G	Phase 6 Red Driver
H	Phase 5 Red Driver
J	Phase 5 Yellow Driver
K	Phase 5 Ped Clear Driver
L	Phase 5 Don't Walk Driver
M	Phase 5 Next
N	Phase 5 On
P	Phase 5 Veh Call Det
R	Phase 5 Ped Call Det
S	Phase 6 Veh Call Det
T	Phase 6 Ped Call Det
i	Phase 5 Green Driver
j	Phase 5 Walk Driver
k	Phase 5 Check
m	Phase 5 Hold
n	Phase 5 Omit
p	Phase 6 Hold
q	Phase 6 Omit
r	Phase 7 Omit
s	Phase 8 Omit
t	Phase 8 Veh Call Det
u	Red Rest Mode Ring 2
v	Omit All Red Ring 2
w	Phase 8 Ped Clear Driver
x	Phase 8 Ped Green Clear Driver
y	Phase 7 Don't Walk Driver
z	Phase 6 Don't Walk Driver
AA	Phase 6 Ped Clear Driver

U	Phase 7 Ped Call Det	BB	Phase 6 Check
V	Phase 7 Veh Call Det	CC	Phase 6 On
W	Phase 8 Ped Call Det	DD	Phase 6 Next
X	Phase 8 Hold	EE	Phase 7 Hold

TABLE 02890 – 3
CONNECTOR C (cont'd)

Pin	Function	Pin	Function
Y	Force Off Ring 2	FF	Phase 8 Check
Z	Stop Timing Ring 2	GG	Phase 8 On
a	Inhibit Max Termination Ring 2	HH	Phase 8 Next
b	Spare 1	JJ	Phase 7 Walk Driver
c	Coded Status Bit C Ring 2	KK	Phase 7 Ped Clear Driver
d	Phase 8 Walk Driver	LL	Phase 6 Walk Driver
e	Phase 8 Yellow Driver	MM	Phase 7 Check
f	Phase 7 Green Driver	NN	Phase 7 On
g	Phase 6 Green Driver	PP	Phase 7 Next
h	Phase 6 Yellow Driver		

c. Cabinet Material.

(1) Pole mounted cabinets (required for two and three phase nonexpendable controllers) shall be fabricated from cast aluminum or welded sheet aluminum or a combination of both. All welds wherever possible shall occur on the inside surfaces of the cabinet to maintain a clean appearance. Where necessary for hinge attachment, welds outside of the cabinet shall be smooth, clean, neat in appearance, and painted to match the cabinet.

(2) Base mounted controller cabinets shall be installed as shown and fabricated from welded sheet aluminum or welded, copper bearing, 14 gauge (min.) sheet steel painted inside and outside with zinc chromate primer and two coats of high grade aluminum paint. All welds wherever possible shall occur on the inside surfaces of the cabinet to maintain a clean appearance. Where necessary for hinge attachment, welds outside of the cabinet shall be smooth, clean, neat in appearance, and painted to match the cabinet.

d. Front Door.

The cabinets shall have a right hinged front opening door, which shall include substantially the full area of the cabinet front and one auxiliary police door-in-door for access to emergency controls. The main door shall be equipped with a positive hold-fast device to secure the door in at least two open positions, one position being approximately 90 degrees open and the other at 120 degrees or more. The hold-fast device shall be easily secured and released without the use of tools. Each door shall be furnished with a neoprene rubber door dealing gasket to assure the weatherproof integrity of the cabinet doors when closed. The main cabinet door shall employ two or three heavy duty hinges which shall be welded to the cabinet and door with hinge pins of ¼ inch diameter (minimum) stainless steel. No "piano" hinges or riveted construction shall be acceptable. The police panel door shall employ hinges meeting the above requirements.

e. Front Door Lock.

The main door shall have a pin tumbler cylinder lock, conforming to the City of Memphis Master Key as registered with the Corbin Lock Company. The Memphis Key Code shall be furnished with the approval of the equipment. The auxiliary police door shall be furnished with a standard police subtreasury lock. One (1) key for each lock shall be provided with each controller .

f. Frame.

(1) Base mounted cabinets shall be furnished for multiphase controllers which have a frame capable of providing four (4) to eight (8) phases. All controllers supplied with railroad preemption equipment shall be furnished in base mounted cabinets. All hardware for mounting on a concrete foundation shall be furnished including Hot Dip Galvanized anchor bolts, nuts, washers, and template. All other controllers shall be furnished in pole mounted cabinets.

(2) Pole mounted cabinets for two phase and three phase non-expandable controllers shall be equipped with brackets for stainless steel banding to either wood or steel pole mounting.

g. Ventilation.

All cabinets shall be furnished with a thermostatically operated, roof mounted electric exhaust fan. Pole mounted cabinet fans shall be capable of moving 100 cubic feet of air per minute at cabinet temperature above 100 degrees Fahrenheit. Base mounted cabinets shall have fans rated at 200 CFM at 100^0F. The fan shall be equipped with long lasting permanently lubricated bearings for constant unattended operation. The exhaust fan shall be mounted in a rain tight housing attached to the cabinet top. The thermostat shall be adjustable from 70^0F to 160^0F.

(1) Pole mounted cabinets shall be furnished with a screened inlet vent in the bottom of the cabinet, equal to or greater in cross section than the top vent. The screened inlet shall be mounted flush with the interior floor of the cabinet. A protrusion, if any, shall project out on the bottom exterior of the cabinet. A replaceable, fiberglass, borderless filter shall be securely mounted over each vent.

(2) In base mounted cabinets the inlet ventilation openings, located in the lower part of the cabinet, shall be screened and fitted with a fiberglass, furnace type, replaceable air filter of adequate size and capacity to pass a volume of air equal to or greater than the rated capacity of the fan. The air filter supplied shall be a type and size which is readily available commercially.

h. Dimensions.

All cabinets for the controllers shall be consistent with the following minimum and maximum dimensions and equipment locations:

(1) Top shelf positioned to allow a minimum of 4 inches above controller to top of cabinet and 4 inches on each side of controller to the sides of the cabinet.

(2) Second shelf positioned approximately 8 inches below the top shelf to allow for a 6 inch high amplifier with a 2 inch space between top of amplifier and bottom of top shelf.

(3) Width of cabinet must allow at least 2 inches clearance on each side between the amplifiers positioned on the second shelf and the terminal strips mounted on the sides of the cabinet.

(4) Third shelf (optional) required if the top and second shelves will not accommodate the conflict monitor, amplifiers, preemptor (if required), and other equipment as required. The third shelf shall allow for the same top and side clearances as on the second shelf.

(5) Load switches to be mounted below the bottom shelf at the left rear of the cabinet. With the load switches in their bases, a minimum clearance of 2 inches shall be maintained below the bottom shelf and from the terminal block as mounted on the sides of the cabinet.

(6) Field connectors to be made at the bottom rear of the cabinet on horizontal terminal strips. Terminal strip blocks shall be positioned not less than 2 inches nor more than 4 inches from the cabinet bottom.

(7) Field loop connections to be made on terminal strips located on the left wall of the cabinet below the bottom shelf.

(8) Loop amplifier cabinet connections to be made on terminal strips on the left wall of the cabinet at the same level as that of the loop amplifier shelf with connections available for AC+, AC-, logic common, and the appropriate input to the controller for each module.

(9) Cabinet power connections to be made on the right wall of the cabinet below the bottom shelf and 2 to 4 inches above the bottom of the cabinet.

(10) The maximum outside dimensions of a base mounted cabinet (exclusive of mounting flanges) shall not exceed 56 inches in height, 48 inches in width, and 36 inches in depth.

i. Other Cabinet Facilities.

Other cabinet facilities shall be furnished as follows:

(1) A minimum of two, fully adjustable metal shelves with brackets to support controller, signal monitor, detector amplifiers, and other accessory equipment. The shelves shall be capable of vertical adjustment through virtually the full height of the cabinet.

(2) Electric service line terminals for 6 gauge copper with 30 ampere circuit breaker line protection.

(3) 120 volt duplex convenience receptacle with separate 30 ampere circuit protection.

(4) Insulated barrier terminals to be used for detector field connections, AC power supply for amplifiers, and controller inputs from amplifiers. Quantities of terminals shall be supplied for the above connections as follows:

2 phase controllers – 24 terminal positions
3 and 4 phase controllers – 36 terminal positions
5 to 8 phase controllers – 48 terminal positions

(5) Grounded neutral buss with multiple screw terminals for 12 gauge copper signal neutrals and 4 gauge copper earth connection.

(6) Insulated barrier terminals (two positions per phase module) for connection of 12 gauge copper pedestrian detector field wires. A 36 volt ziner diode shall be installed across each pedestrian detector field terminal to ground.

(7) Insulated barrier terminals (five positions per phase module) for connection of 12 gauge copper signal display field wires. A 150 volt, 20 amp Varistor shall be installed across each signal field terminal to ground.

(8) Insulated barrier terminals (four positions) for connection of 12 gauge copper system interconnect lines. A 150 volt, 20 amp Varistor shall be installed across each system interconnect terminal to ground.

(9) Insulated barrier terminals for internal wiring interconnection of all other cabinet accessories and circuitry.

(10) All barrier terminal blocks shall consist of twelve (12) terminal pairs using a minimum of ten 32-size screws with the minimum center-to-center distance between terminal pairs being 5/8 inch. Terminal blocks shall be furnished with an engraved or indelibly printed numbering strip attached with screws to the terminal block. This type and size terminal block shall be provided for all applications including controller inputs and outputs, field connections, and detector connections.

(11) a 120 VAC, 8 watt, florescent light fixture mounted on the cabinet ceiling at the front of the cabinet. Fixture shall employ #F8T5, 8 watt, florescent tube. An on/off switch for the light shall be mounted on the inside of the main cabinet door.

(12) Detector micro switches shall be provided for placing vehicular and pedestrian calls on each individual phase separately. A sufficient number of switches shall be provided to serve the maximum phase capability of the controller unit. All switches are to be permanently labeled and identified.

(13) An on/off power switch shall be mounted on the inside of the main cabinet door to disconnect all equipment in the cabinet from the 120 VAC service line current with the exception of the cabinet light and the duplex convenience receptacle.

(14) An automatic/flashing switch shall be mounted on the inside of the main cabinet door to preempt the normal signal display and initiate the specified flashing display. The controller shall continue to operate during this flashing mode.

(15) A signal on/off switch shall be mounted on the inside of the main cabinet door to disconnect all vehicle and pedestrian signal heads but to allow controller and associated cabinet equipment to operate.

(16) In cabinets for use with preemption equipment, a preempt test switch shall be mounted on the inside of the main cabinet door which will place a preemption call to the control equipment.

(17) All cabinet wiring shall be neatly bundled and attached to the sides and back of the cabinet.

(18) Other accessory equipment shall be provided as specified in other sections of these Specifications.

j. Police Compartment.

All cabinets shall be furnished with a police compartment accessible through the door-in-door. The back side of the compartment extending into the cabinet shall have all exposed electrical facilities enclosed in a protective housing. The police compartment shall be furnished as follows:

(1) On/off power switch to operate same as the main on/off switch, above.

(2) An automatic/flashing switch with a flashing position to permit the normal red, yellow, and green signal display to be preempted to the flashing operation. Power shall be removed from the controller unit during this flashing mode. Upon resuming automatic operation, the controller display shall be in the preprogrammed start up orientation.

(3) A normal/manual switch so that, when in manual position, this switch shall stop the automatic sequence of the controller and hold the then existing display until manually advanced into the next interval. When in normal position, the automatic controller sequence shall continue.

(4) A miniature panel connector for connecting a detachable hand held push button for manual operation. The connector shall have three (3) male pins and mate with a screw-on type, coarse threaded, female connector plug.

(5) A high quality retractile cord with molded hand held push button with attached connector plug for engaging the connector described above. The retractile cord shall be capable of an extension of 7 feet (minimum) and shall be stored in the police compartment when not in use.

k. Expansion.

(1) The cabinet for four to eight phase controllers shall be furnished of sufficient size to accommodate the control equipment described, a coordinating unit, and eighteen (180 loop detector amplifiers. The cabinet for two and three phase controllers shall be sized as above for eight (8) loop detector amplifiers and a coordinating unit.

(2) The cabinet shall have provisions for all additional equipment associated with the future expansion to full functional capability, including but not limited to load switch bases, complete cabinet wiring, field connection terminals, and detector terminals.

3. Controller Timer.

a. Controller Timer Design.

(1) General.
The controller timer unit shall be of modular design utilizing plug-in circuit boards and an internal power supply, all mounted in and housed by a suitable sheet metal enclosure. All solid-state controller logic circuitry shall be mounted on plug-in printed circuit modules mated to connectors mounted on a back panel “Mother Board” and removable from the front of the controller chassis without the use of tools. The back panel, or “Mother Board”, shall have no logic circuitry mounted on it. A separate plug-in module shall be exclusively designated and provided for each phase. This phase modular design shall preclude any phase module being associated with the operation of more than one (1) phase. The time setting switches, phase associated function controls, and phase status indicator lights shall be mounted on the front panel of the phase module with which they are associated. Other plug-in modules, removable from the front of the controller chassis, shall be provided for sequence control, input/output interfacing, other controller logic and memory circuitry, and controller status indicator lamps. A plug-in module for the power supply is optional.

(a) The pin connector(s) shall be front mounted. Each phase board position in the controller chassis shall be capable of accepting any type of phase module designed for that model controller. Each phase module shall be capable of being interchanged with all phase modules in the controller. All modules shall be interchangeable with like modules from like controllers.

(b) Provisions shall be made for future expansion of two and three phase controllers to four phases and five to seven phase controllers to eight phases through the substitution of addition to the controller frame of phase modules. The phase sequencing and timing circuitry initially provided shall be capable of controlling all phasing up to the maximum capability of the controller frame without modification. Unused spaces shall be covered with blank panels.

(c) Each module shall be identified according to function and labeled in a professional and permanent manner.

(d) The control unit enclosure shall bear a name plate plaque with an ingrained identifying serial number.

(e) All printed circuit boards shall be of fiberglass, epoxy construction with a minimum2 ounce copper circuit track and comply with NEMA TS 1-4.2.02.

(2) Interchangeable Units.
The control unit shall be furnished consistent with a standard model designation and registration, and it shall be capable of being removed and replaced with other units of the same model and type as well as with other controllers which comply with NEMA TS 1, Part 3 (Interface Standards) without the use of any kind of adapter.

(3) Load Switches.
Solid-state, three circuit, signal load switches shall comply with NEMA TS 1-5.01. These switches shall isolate the 24 volt DC signal logic outputs of the controller from the 120 VAC power line and field terminals so as to prevent high energy line transients from entering the controller unit. Each load relay circuit shall optically isolate the field terminal form the controller, shall turn on at zero volts, and be rated at 25 amps output load at 120 VAC. (Teledyne Relay #621-4, or Crydom Relay TC 2623 or equal.) Load switches for vehicular and pedestrian indications shall be interchangeable. Each output shall be driven by a separate controller output. No logic circuitry is permitted in load switches. No reed switches are permitted.

(4) Dual Maximums.
The controller shall be furnished with dual maximum green limits on all actuated phases which are not required to have volume/density features. The second maximum limit shall be timed by internal controller circuitry. No external timers shall be permitted. The selection of Maximum Limit 1 or 2 shall be by either remote selection or time clock(s) and with selection of the Maximum Limit 1 or 2 for a particular phase being independent of the selection of Maximum Limit 1 or 2 for any other phase.

(5) Status Lights.
The control unit shall be furnished with status lights indicating the interval(s) and phase(s) being timed, whether Max I or Max II is timing, the justification for phase termination, rest state, phase(s) next and pedestrian and vehicular detector actuations. An easily accessible switch shall be provided for extinguishing incandescent indicator lights when they are not in service. All indicator lights are to be of sufficient brightness to be legible while exposed to direct sunlight.

(6) Digital Timing.
Digital timing utilizing the 60 hertz frequency of the electrical service line as a counting reference shall be used for all intervals. Any interval shall not deviate more than 0.100 seconds from its true time setting.

(7) Time Setting Switches.
All interval time settings shall be registered on individual pairs of ten (10) position rotary thumbwheel switches, front mounted on their respective phase modules, and providing discrete positions for each setting. The switch positions shall be consecutively numbered 0 through 9 and appropriately labeled such that each switch provides a legible indication of the setting directly readable from the front panel. Switch pairs shall be labeled according to function and preferably color coded according to interval. Phase board mounted switches shall be provided for Detector Memory (Locking/Nonlocking) and for minimum vehicle recall, maximum vehicle recall, pedestrian recall, and nonactuated operation (on phases with concurrent pedestrian timing).

(8) Coordination Capability.
All controllers shall be capable of coordinated control under the supervision of a local or master coordinated system. Any phase of a multi-phase controller shall be capable of coordination.

(9) Temperature Range.
The operation of the controller and all auxiliary equipment shall not be adversely affected when subjected to ambient air temperatures between -30^0F and $+165^0$F at 95 percent maximum relative humidity (Subjected to test in NEMA TS-1 Part 2).

(10) Master Digital Clocks.
The controller shall have one and only one set of master digital clocks to time all intervals of all phases. Separate clocks associated with and/or located on individual phase boards are prohibited.

(11) Auxiliary Power Supply.
The control unit shall have a self-contained power supply to operate the controller and all auxiliary equipment. The power supply shall operate from an electric service line with input voltage from 95 to 135 volts, 60 hertz, and develop stabilized controller voltages for continuous controller operation with interval timing remaining within specified tolerances. The power supply shall be separately and independently fuse protected for both the 120 VAC input and 24 VDC output with easily accessible fuses. No internal fuses are permitted. DC output for external circuitry shall be rated at a minimum of 0.5 AMP and capable of direct short circuit without internal damage to the power supply. All components of the power supply shall be amply derated with respect to heat dissipating capacity so that any extreme ambient temperature and applied voltage shall result in neither a material shortening of component life nor severe deterioration of operational characteristics. The power supply shall be capable of operating the controller when expanded to its maximum capabilities complete with all auxiliary equipment . No auxiliary or external power supplies are permitted.

(12) Logic Levels.
All controller input and output logic levels shall be a nominal zero volts (low state) for the True state and a nominal +24 volts for the False state.

(13) Logic Inputs.
Each controller shall provide the following input functions to modify controller operation, as defined below:

(a) Phase Omit:
One per phase – as per NEMA (not applicable on two phase controllers).

(b) Force Off:
One per controller, one per ring on dual ring units – as per NEMA.

(c) Hold:
One per phase – as per NEMA.

(d) Stop Timing:
One per controller, one per ring on dual ring units – as per NEMA.

(e) Inhibit Maximum Termination:
One per controller, one per ring on dual ring units – as per NEMA.

(f) Select Second Maximum:
One per controller, one per ring on dual ring units. When activated, this input shall

cause the Second Maximum time setting to be in effect on the phase(s) timing. When deactivated, the First Maximum time setting shall be in effect.

(g) Interval Advance:
One per controller – as per NEMA. It advances the controller to serve only vehicle and/or pedestrian demands which are registered by normal actuation.

(h) Manual Control Enable:
One per controller. When activated, it places vehicle and pedestrian calls on all phases, stops timing in all intervals except the vehicle change (yellow) and all red intervals. These vehicle clearance intervals are timed by the controller according to their respective settings.

(i) External Start:
One per controller. When activated, the controller will immediately revert to the preprogrammed initialization interval and display.

(j) Omit Red Clearance:
One per controller, one per ring on dual ring units – as per NEMA.

(k) Call To Nonactuated Mode:
Two separate inputs per controller – as per NEMA.

(l) Walk/Rest Modifier:
One per controller. When activated, it causes nonactuated phases to rest in a timed out WALK interval and display in the absence of a conflicting call for service. When not activated, a nonactuated phase will proceed to Green Rest in a timed out DON'T WALK state.

(m) Pedestrian Recycle:
One per controller, one per ring on dual ring units, when activated:

1. In actuated mode, calls for pedestrian service will cause pedestrian recycling of that phase if HOLK is applied. This is regardless of the existence of conflicting calls.

2. In nonactuated mode, pedestrian intervals will be recycled when phase has reached Green Dwell (pedestrian clearance timed out) and pedestrian omit is not active.

(n) Red Rest:
One per controller, one per ring in dual ring units – as per NEMA.

(o) Test Inputs:
Two per controller – as per NEMA.

(p) Omit Pedestrian:
One per phase. When activated, it prohibits a phase from being selected for service due to a pedestrian actuation or for a pedestrian call to be serviced on a phase. Pedestrian intervals in progress are not affected.

(q) Remote Minimum Recall:
One per controller. When activated, it causes a call for minimum vehicle service to be placed on all phases.

(r) Vehicle Detector Call:

One per phase – as per NEMA.

(s) Pedestrian Detector Call:
One per phase – as per NEMA.

(t) Logic Input Priorities:
The following table lists from highest to lowest priority all logic inputs. The higher priority input shall override the inputs listed below it.

1. Initialization (Power Up)
2. External Start
3. Phase Omit
4. Pedestrian Omit
5. Interval Advance
6. Stop Timing
7. Manual Control Enable 9except inhibits Interval Advance during yellow and all red intervals).
8. Force Off
9. Hold

(14) Logic Outputs.
Each controller shall provide the following Logic Outputs as load switch drivers, controller status, and for external logic use.

(a) Vehicle Load Switch:
Three per phase—red, yellow, and green – as per NEMA.

(b) Pedestrian Load Switch:
Three per phase—Walk, Pedestrian Clearance, and Don't Walk – as per NEMA.

(c) Overlap Load Switch:
Four separate, programmable three circuit overlap outputs per controller, except three overlaps in three phase units and no overlaps in two phase units.

(d) Check:
One per phase – as per NEMA. Active only when the phase is not green and a demand for service is existing for that phase.

(e) Phase On:
One per phase – as per NEMA.

(f) Phase Next:
One per phase, except not applicable to two phase units, active when that phase is committed to be serviced next and remains active until that phase begins timing. Phase next shall be determined at the end of the Green interval of the terminating phase. The phase next commitment is irreversible.

(g) Voltage Monitor:
One per controller—an open collector which is active (low state) as long as the internal power supply voltages are within safe tolerances. This output is monitored by the failsafe monitor.

(h) Flashing Logic:
One per controller—a true/false logic output with a one-pulse-per-second rate and 50 percent duty cycle.

(i) +24 Volts DC External Power Supply:
One per controller—provides +24 VDC plus or minus 2V output for external use with 0.5 ampere capacity.

(j) Coded Status Bits:
Three bits per controller, six bits in dual ring controllers. Bits A, B, and C for Ring 1 and Ring 2 indicate controller status according to Table 02890 – 4.

TABLE 02890 – 4

CODED STATUS BIT CONTROLLER STATUS CODES

Code No.	Bits* C B A	Interval (s) Timing Actuated	Nonactuated	Vehicular Signal	Pedestrian Signal
0	0 0 0	Minimum (Maximum) or Walk and Ped. Cl.	Walk	Green	Walk / Flash Don't Walk
1	0 0 1	Extension	Walk-Hold	Green	Walk
2	0 1 0	Maximum	Ped. Clear or Min. Green	Green	Flashing Don't Walk
3	0 1 1	Green Rest	Green Rest	Green	Don't Walk
4	1 0 0	Yellow Change	Yellow Change	Yellow	Don't Walk
5	1 0 1	All Red	All Red	Red	Don't Walk
6	1 1 0	Red Rest	Red Rest	Red	Don't Walk
7	1 1 1	Spare	Spare	Spare	Spare

* One (1) indicates True output; 0 indicates False output.

(15) Start-up Orientation.
The controller shall have a predetermined start-up orientation which shall be programmable to allow start-up to begin with any phase green or yellow interval. Upon application of the line current to the controller, the designated start-up orientation shall provide the corresponding signal display. Upon a power interruption of 500 milliseconds or less, the controller shall continue operation when power is restored as though the interruption had not occurred. If the duration of a power interruption exceeds 1,000 milliseconds, the controller may resume operation in the start-up orientation. The controller may resume operation in the start-up orientation or maintain its normal orientation if the power interruption has a duration of more than 500 but less than 1,000 milliseconds.

(16) Overlap Circuitry.
The controller shall provide internally generated overlap circuitry for the Red, Yellow, and Green signals of four phases. The overlaps shall e programmable on a program circuit board removable from the front of the controller. The controller shall be preprogrammed for overlaps by the manufacturer according to applicable sequence chart which is included on the Plans. All three phase controllers shall provide internally generated overlap circuitry for the Red, Yellow, and Green signals of three phases. No external overlap circuitry is permitted. This section does not apply to two phase controllers.

(17) Volume Density Facilities.
All controllers with five through eight phases shall be furnished with Volume Density facilities and separate but concurrent pedestrian timing on all actuated through phase modules. All "LAST CAR PASSAGE" functions shall be omittable on controllers furnished with Volume-Density facilities.

(18) Quad Left Operations.
All five through eight phase controllers shall normally employ dual ring, quad left operation which shall allow concurrent but independent timing of any two nonconflicting phases as per NEMA 4.1. The availability of additional programmable sequence patterns (such as eight phase sequential, etc.) is desirable.

(19) Single Entry Mode.
All controllers shall operate in a single entry mode, with all phases independent of each other (NEMA 4.1.03-B).

(20) Blank Phase Module Panels.
All four phase controllers shall be supplied with on (1) blank phase module panel. All eight phase controllers shall be supplied with two (2) blank phase module panels.

b. Controller Timer.

(1) General Operation.

(a) Normal assignment of right-of-way by the controller shall conform to the local demands of traffic according to the phase sequence shown on the Plans and as registered by vehicle actuation of detectors, pedestrian operation of push buttons, or in coordination with a remote master system.

(b) Facilities shall be available for signal preemption by external command for priority traffic movement.

(c) Other assignment of right-of-way shall be manual, by maintenance personnel or traffic official.

(d) If no vehicle actuation occurs and all timing is complete, the traffic controller shall retain the green indication of the last phase served until an actuation occurs on a conflicting phase or phases (Red Rest function shall be omittable).

(e) "Recall" circuitry for both vehicle and pedestrian movements shall be furnished for each actuated phase, which may be operated to insure the activation of the phase and/or designate "parent" phase or for automatic return of right-of-way. Switches on the front of each phase module shall be provided to independently energize the "Recall" circuit for each vehicular and pedestrian movement.

(f) The all-red interval on each phase module shall be independently omittable.

(g) Separately adjustable pedestrian timing shall be furnished on each artery and cross street through-phase module. Actuated pedestrian timing shall be required with vehicle-actuated movements and nonactuated pedestrian timing for nonactuated vehicle movements.

(h) Locking/nonlocking vehicle detector memory modes with front-mounted switches for independent per phase selection shall be furnished on all actuated phase modules; "Locking" for registration and retention of momentary vehicle detection inputs and "Nonlocking" for full presence type detection (memory disabled).

Under no operational circumstances shall a vehicle detector input be retained in memory after its termination when the "Nonlocking" mode is in operation.

(i) Pedestrian detection shall be the momentary contact closure of a pedestrian push-button circuit and shall be retained until served.

(2) Vehicle-actuated Phase Operation.

(a) A demand for vehicular service shall be registered on a phase, and the indicator for vehicle service on that phase shall illuminate and remain so until the demand is served. Each vehicle actuation received during the green interval shall illuminate an actuation indicator. The phase receiving the right-of-way shall time the minimum green interval. In the absence of demand for another phase, right-of-way shall remain on the currently timed phase. At the time a demand for service is placed for another phase, the limit of maximum green shall begin timing and retention of right-of-way in the extension interval shall be dependent upon overlapped unit extensions. If the demand for service on the conflicting phase is terminated, the maximum timer shall cease timing and reset to zero to begin timing again upon conflicting phase demand for service. If vehicle actuation spacing exceeds the unit extension, the phase terminates with the change (yellow) interval and all-red interval and right-of-way will transfer to the next phase having demand, in accordance with the sequence chart. If vehicle actuation spacing is less than the unit extension, the phase shall extend to the maximum green limit and terminate with the change (yellow) interval and all-red interval and right-of-way will transfer to the next phase having demand, in accordance with the sequence chart.

(b) When a phase is terminated by the maximum green limit, or when an actuation is placed during the change (yellow) or red intervals, a vehicle call will be placed on the phase and the right-of-way shall be returned to this phase at the first opportunity permitted in the controller sequence; except, if the phase is operating with nonlock detection, the right-of-way will be returned only if a presence call is existing at the time when the normal sequencing allows the return of right-of-way to that phase. The phase next decision shall be made at the end of the green interval of the terminating phase. This decision if irreversible; and even if the designated "phase next" detector memory is disabled and its demand for service leaves during the timing of the change (yellow) or all-red intervals of the terminating phase, the controller shall nevertheless proceed to provide a right-of-way to the "phase next." The "phase next" indicator shall be illuminated on the designated phase module during and only during the change (yellow) and all-red intervals immediately preceding that phase obtaining service. Any actuated phase for which there is no actuation will be skipped.

c. Phase Module Intervals.

(1) Vehicle Actuated Phase Timing Intervals.
The basic actuated phase shall provide the following timing intervals; note that names of intervals may vary with manufacturer:

(a) A minimum green interval consisting of a minimum initial interval or a minimum initial interval plus one unit extension. This shall be the minimum length of time that a phase shall receive the right-of-way for vehicular demand only.

(b) A unit extension interval during which traffic actuations spaced less than a unit extension apart can retain right-of-way in the presence of demand for another phase. The timing of a unit extension interval will terminate upon the receipt of a subsequent vehicle actuation and will begin timing another extension interval when the actuation

has terminated.

(c) A maximum green interval which shall be the maximum time that a phase may retain right-of-way by successive actuations less than one unit extension apart during the existence of a demand on a conflicting phase. The maximum timer begins and continues timing only when a call for service is present on another phase. Should the conflicting demand cease, the maximum timer is reset to zero. If the phase is on "Maximum Recall", the maximum timer shall time as if a demand for service is always existent.

(d) A change or yellow interval which shall immediately follow the termination of the green display on any phase.

(e) An omittable all-red interval which shall follow the change or yellow interval and precede the yielding of right-of-way to the conflicting phase which has been designated as the "Phase Next".

(f) Each vehicle-actuated phase shall be governed separately by the timing interval controls with the typical limits shown in Table 02890 – 5. Timing of each interval shall be accurate within plus or minus 0.1 second of the indicted setting.

TABLE 02890 - 5

TYPICAL LIMITS OF TIMING INTERVALS (VEHICLE ACTUATION)

Interval	Limits (Seconds)
Minimum Initial Interval	0-99 (in 1 second increments)
Unit Extension	0-9.9 (in 1/10 second increments)
Maximum Green Limit	0-99 (in 1 second increments)
Vehicle Change (Yellow)	0-9.9 (in 1/10 second increments)
All-Red Interval	0-9.9 (in 1/10 second increments)

(2) Vehicle and Pedestrian-Actuated Phase Operation.
Phase modules for concurrent, but separate, pedestrian and vehicular timing shall be furnished with the following operation in addition to the operation of the vehicle module:

(a) The pedestrian intervals shall be called by a momentary contact closure of a button and shall be two fixed intervals, Walk and Pedestrian Clearance, not extendible by repeated push-button actuations. Such actuation shall cause the pedestrian demand indicator for that phase to illuminate and remain so until the demand is served.

(b) With no push-button actuation, a steady "DON'T WALK" signal shall be displayed at all times whenever the right-of-way is transferred to the associated vehicle phase. A steady "DON'T WALK" signal shall be displayed during that phase's change (yellow) and red intervals.

(c) During the timing of the pedestrian intervals, the corresponding vehicular phase shall receive and retain the right-of-way and the vehicular intervals shall be timed concurrently with, but separately from, the pedestrian intervals.

(d) When the right-of-way is transferred to a vehicular phase having pedestrian timing and a pedestrian call has been received on that phase, a steady "WALK" signal shall be displayed for the pedestrian movement for a predetermined time and shall be followed by a predetermined "PEDESTRIAN CLEARANCE" interval,

displayed as a flashing "DON'T WALK" signal. The vehicular intervals and the pedestrian intervals on the same phase shall begin timing simultaneously and time concurrently with the longer of the two prevailing to retain right-of-way on that phase. Timing of the pedestrian intervals shall not be truncated for any reason, including reaching the maximum green limit or receipt of a force-off command. If the vehicular intervals extend the right-of-way beyond the pedestrian intervals, a steady "DON'T WALK" shall be displayed by the pedestrian signal during that period.

(e) A pedestrian actuation without an accompanying vehicle actuation shall transfer the right-of-way to the phase called for a minimum of one pedestrian "WALK" interval; on "PEDEDSTRIAN CLEARANCE" interval; and, optionally one unit vehicle extension interval. Vehicle actuations that occur during and after the timing of the "WALK" and "PEDESTRIAN CLEARANCE" intervals shall be accepted and can extend that phase vehicle right-of-way in the normal manner up to the maximum green limit.

(f) In the absence of actuations on any conflicting phase, a pedestrian actuation on a phase with vehicle right-of-way shall reinitiate the normal pedestrian interval timing and display.

(g) Except as indicated in the paragraph above, a pedestrian actuation occurring at other than the "WALK" interval of the current timing phase shall be retained in memory until the normal phase sequencing returns the right-of-way to the phase called. A pedestrian actuation occurring during the WALK interval of the phase being timed shall be disregarded.

(h) Each actuated phase with pedestrian timing shall be governed separately, as indicated, and shall include the timing interval controls with the typical limits shown in Table 02890 – 6. Timing of each interval shall be accurate within plus or minus 0.1 second of the indicated setting.

TABLE 02890 - 6

TYPICAL LIMITS OF TIMING INTERVALS (VEHICLE AND PEDESTRIAN ACTUATION)

Interval	Limits (Seconds)
Minimum Initial Interval	0-99 (in 1 second increments)
Unit Extension	0-9.9 (in 1/10 second increments)
Maximum Green Limit	0-99 (in 1 second increments)
Vehicle Change (Yellow)	0-9.9 (in 1/10 second increments)
All-Red Interval	0-9.9 (in 1/10 second increments)
Pedestrian Walk	0-99 (in 1 second increments)
Pedestrian Clearance	0-99 (in 1 second increments)

(3) Volume-Density Features.
When phases are equipped with volume-density features, the following functions shall be provided in addition to those set forth in the actuated phase section of the Specification.

(a) A variable initial will be timed within predetermined limits and be proportional to the number of actuations received on that phase before transfer of right-of-way to that phase. If the number of actuations received before the right-of-way transfer provides a variable initial less than the preset minimum initial, the minimum initial timing shall prevail. Maximum variable initial shall be fixed at 30 seconds.

(b) The unit extension timing shall be variable within preset limits and shall be reduced from an upper limit to a lower limit at a rate proportional to the waiting time of an unserved call on a conflicting phase or phases.

(c) Each phase equipped with volume-density features shall be furnished with the timing interval controls shown in Table 02890 – 7, in addition to the controls previously specified under vehicle and pedestrian-actuated phases in the specification. Timing adjustments shall be accurate within plus or minus 0.1 second of the indicated setting.

TABLE 02890 - 7

TYPICAL LIMITS OF TIMING INTERVALS (VOLUME-DENSITY FEATURES)

Interval	Limits
Time Before Reduction	0-99 Seconds (in 1 second increments)
Seconds Per Actuation	0-9.9 Seconds (in 1/10 second increments)
Time to Reduce	0-99 Seconds (in 1 second increments)
Minimum Gap	0-9.9 Seconds (in 1/10 second increments)

NOTE: Maximum Gap is equal to the unit extension setting.

(d) Time before reduction establishes a preset time before the maximum gap begins to reduce. Time before reduction begins with demand for service on a conflicting phase.

(e) Seconds per actuation establishes the number of seconds each vehicle actuation increases the variable initial from zero during the non-green interval of the phase; maximum variable initial is 30 seconds.

(f) Time to reduce establishes the time in which the allowed gap is reduced from maximum gap to minimum value to which the allowed gap is reduced upon the expiration of time to reduce.

(g) Minimum gap establishes the minimum value to which the allowed gap is reduced upon the expiration of time to reduce.

(h) All phases having volume-density functions shall be furnished with calling detector circuitry in the cabinet that shall inhibit the registration of calls from selected detectors during that phase's green interval while allowing normal registration of calls from other detectors to that phase.

(4) Nonactuated Phase:
The right-of-way shall remain on the nonactuated phase until a demand is placed on an actuated phase. Following termination of the actuated phase, the right-of-way shall return to the non actuated phase and the minimum green shall be timed. The minimum green shall consist of an initial green interval, plus a PEDESTRIAN CLEARANCE interval. During the initial green interval a pedestrian "WALK" interval shall be displaced and timed. The timing of the PEDESTRIAN CLEARANCE shall not begin until a demand is placed on an actuated phase. A nonactuated phase shall be governed separately by the following controls readily adjustable for the typical limits shown. Timing of each interval shall accurate within plus or minus 0.1 second.

Interval	Limits
Initial Green (Walk)	0-99 (in 1 second intervals)
Pedestrian Clearance	0-99 (in 1 second intervals)
Vehicle Change (Yellow)	0-9.9 (in 1/10 second intervals)
All-Red Interval	0-9.9 (in 1/10 second intervals)

4. Accessory Equipment.

a. Time Clock Switch.

(1) All time clocks shall be o f the electronic keyboard programmable type with seven day format and skip operation capability. The program must contain a minimum of eighteen instructions to permit up to nine on/off instructions per twenty-four hour period, which can be set in one minute increments. This clock shall not require battery backup. The clock must have a minimum of three (3) single pole double throw independently controllable outputs. These outputs shall be capable of switching a five AMP, 115 VAC resistive load. All poles of a relay are to be brought out to permit full flexibility of control circuitry switching. The normally open contacts shall be provided with a resistor-capacitor snubber to minimize burning and pitting of contracts when used on inductive loads.

(2) If power is lost, an internal capacitor backup shall provide a minimum of 24 hour memory and time keeping continuation from a full charge. When AC power returns after an outage, the outputs shall assume the condition which the program requires at that time. An internal crystal shall provide clocking operation in absence of the 60 HZ line frequency and shall be accurate within 0.003%, or approximately 3 seconds per 24 hour period. The unit shall be housed in a case with a dust cover. Connections from the clock to the cabinet shall be made via a 15 conductor cable with a quick disconnect connector. Two time clocks shall be required for two ring controllers. One time clock shall be provided for Phases 1 through 4 and another time clock shall be provided for Phases 5 through 8. The time clock shall have an automatic daylight savings time function to adjust for this timing change with no additional programming. On single ring controllers, one time clock switch shall be provided for the independent selection of the No. 2 Maximum Green time for each phase module. Cabinet wiring and terminal facilities shall be provided for each phase module such that, by making the appropriate connections from the time clock, any phase Maximum 2 may be selected. On dual ring controllers, a time clock switch for each ring shall be provided as above for the separate independent selection of the No. 2 Maximum Green in that ring.

b. Conflict / Voltage Monitor.

Each controller shall be furnished with a signal conflict / voltage monitor which is capable of monitoring for vehicle-vehicle and vehicle-pedestrian signal conflicts with each phase consisting of four (4) 120 volts AC inputs—GREEN, YELLOW, WALK, and RED. The units shall also be capable of monitoring output voltages at the field terminals for RED signals and for satisfactory internal DC voltages of the controller with which they are associated. Detection of any conflicting signal or missing or unsatisfactory voltages shall cause operation of the monitor units output circuit to energize external relays to automatically switch control of the intersection signals to flashing operation.

(1) Basic Capability.

(a) The CONFLICT MONITOR portion of the MONITOR unit shall be capable of monitoring conflicting signal indications at the field connection terminals of the controller assembly. For purposes of conflict determination, a signal on any of the GREEN, YELLOW, or WALK inputs associated with a channel shall be considered

as that channel being in service.

(b) The VOLTAGE MONITER portion of the MONITOR unit shall detect the absence of any required RED signal voltage at the field connection terminals of the controller assembly. For this purpose, a signal of any of the GREEN, YELLOW, WALK, or RED inputs associated with a channel shall be considered as that channel being in service.

(c) The VOLTAGE MONITOR portion of the MONITOR shall be capable of monitoring the CONTROLLER UNIT VOLTAGE MONITOR output which indicates satisfactory operating voltage in the controller unit and the +24 volt DC inputs.

(2) Connectors.
All inputs and outputs, including power, shall enter the unit through front panel connectors. The connectors shall conform to the provisions of Military Specification MIL-C-26482. Connector pin terminations shall conform with Table 02890-8 under Pin Assignments. A wire harness shall connect the MS Connector to the cabinet terminals.

(3) Size.
The overall dimensions of the MONITOR units, including mating connector and harness, shall not exceed the following:

Type 3 4 ½" W x 7" H x 11" D
Type 12 4 ½" W x 10 ½" H x 11" D

(4) Environmental Requirements.
The MONITOR shall perform its specified functions under the conditions set forth in NEMA Standards Publication TS 1-1976, Part 2, Environmental Standards and test Procedures for Solid-State Traffic Control Assemblies.

(5) Sensing of Load Switch Output for Traffic Signal Displays.

(a) Four inputs shall be provided for each channel to permit the monitoring of voltages at vehicle GREEN, YELLOW, RED, and pedestrian WALK signal field terminals. The unit shall be designed so that it shall not be necessary to terminate unused GREEN, WALK, and YELLOW signal sensing inputs provided that the impedance to AC+ of the connection to each of these inputs is less than the equivalent of 1500 picofarads (pf) between the input lead and AC+ as measured at the input to the unit.

(b) When the circuit connected to the sensing input of the monitoring unit exhibits high impedance characteristics such as caused by dimmers or burned out bulbs, it may be necessary to place a low impedance device between the monitor unit input and AC-(common) external to the monitor unit.

(c) All unused RED signal inputs shall be terminated to AC+.

(d) A GREEN, YELLOW, or WALK signal input shall be sensed when it exceeds 25 volts AC, and a signal input shall not be sensed when it is less than 15 volts AC. Signals between 15 and 25 volts AC may or may not be sensed. Both positive and negative half wave signals shall be sensed. The RED MONITOR signal input shall require the presence of 60 plus or minus 10 volts AC at the field terminal to satisfy the requirements of RED signal indication.

(6) Conflict Monitoring.

(a) When voltages on any conflicting channels are present concurrently for 450 milliseconds, a conflict shall be recognized by the MONITOR. Signals in conflict sensed for more than 200 milliseconds but less than 450 milliseconds may or may not cause the MONITOR to recognize a conflict. Signals in conflict sensed for less than 200 milliseconds shall not cause the MONITOR to recognize a conflict.

(b) When the CONFLICT MONITOR recognizes a conflict, it shall cause two sets of isolated Form C relay contacts to transfer, and these contacts shall remain in this state until the monitor is reset by the activation of a front panel control or the activation of the RESET input. The "Conflict" indicator shall become illuminated. Power interruption shall not reset the MONITOR when the MONITOR unit has been triggered by detection of a conflict. Power shall remain on the controller unit, and a STOP TIME command shall be imposed on the controller until the CONFLICT MONITOR is reset. Power interruption shall not reset the monitor when a conflict has been recognized prior to the power interruption.

(7) Red Monitoring.

(a) The MONITOR shall be capable of monitoring for the absence of voltage on all of the inputs of a channel. If an output is not present on at least one input of a channel at all times, the monitor shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the MONITOR shall not recognize the absence. If the condition exists for more than 1,000 milliseconds, the MONITOR shall recognize the absence. If the condition exists for more than 700 milliseconds but less than 1,000 milliseconds, the MONITOR may or may not recognize the absence.

(b) When the MONITOR recognizes the absence of a voltage on a channel, it shall cause the output relay contacts to transfer. These contacts shall remain in this state until the monitor is reset by the activation of the front panel control or the activation of the RESET input.

(c) Power interruption shall not reset the MONITOR when the MONITOR unit has detected the absence of RED prior to power interruption.

(8) Voltage Monitoring.

The MONITOR shall include a Voltage MONITOR capable of monitoring two +24 volt DC MONITOR inputs and a true state signal applied to its CONTROLLER VOLTAGE MONITOR input. Absence of the proper voltage level at any of the inputs shall cause the VOLTAGE MONITOR to transfer the output contacts. Restoration of ALL proper voltage levels shall reset the VOLTAGE MONITOR. When the MONITOR is reset, an EXTERNAL START command shall be issued to the Controller Unit so the normal operation will resume in the start-up orientation.

(a) +24 Volt DC Supply Monitor.

A voltage greater than +22 volts applied to both of the +24 VOLT MONITOR inputs shall be recognized by the Monitor as adequate for proper operation of the controller assembly. If only one +24 volts DC supply is monitored, the two +24 VOLT MONITOR inputs should be jumpered and connected to that +24 volt DC supply.

A voltage less than +18 volts DC applied to either of the +24 VOLT MONITOR inputs shall be recognized by the monitor as inadequate for proper operation of the controller assembly. This shall cause transfer of the output relay contracts.

Over the voltage range of 0 to 30 volts DC, the maximum current "in" or "out" of the +24 VOLT MONITOR input terminals shall be less than 10 milliamperes. The input impedance to these terminals shall not exceed 11k ohms to 0 volts DC (Logic Ground); and surge impedance shall not be less than 100 ohms.

(b) +24 Volt Monitor Inhibit (Input).
Application of a "true" (Low) state to this input shall inhibit the operation of the two +24 VOLT MONITOR Inputs.

(c) Controller Voltage Monitor (Input).
The MONITOR shall include an input from the controller unit (CONTROLLER UNIT VOLTAGE MONITOR Output). Absence of the "true" (Low) state on this input is an indication of improper operating voltages within the controller unit and shall cause transfer of the MONITOR unit output relay contacts.

(9) Reset.
Activation of the RESET push button on the front panel of the MONITOR UNIT or the RESET input shall cause the two Form C output contacts to transfer to the RESET condition for the duration of either of these inputs. Removal of both of these inputs shall leave the MONITOR in the reset condition only if there are no signal conflicts, no red monitoring failure, and no voltage monitoring failures.

(10) Output.
The output relay of the MONITOR unit shall have two sets of isolated Form C contracts. These relay contacts shall be capable of switching all loads in the range from 2 milliamperes at 18 volts to at least 3 amperes at 135 volts AC. The open circuit of the output relay shall be the circuits which are open when the MONITOR unit is in the "no conflict" state and all voltages are sufficient for proper operation of the controller assembly.

(11) Monitor Unit Power Failure.
The MONITOR unit shall, in addition to the operation described under VOLTAGE MONITORING, be responsive to voltage failure within itself, whether it is the result of over-current protection device operation, absence of AC+, or failure of the MONITOR UNIT power supply.

(12) Indicators.
The MONITORING UNIT shall have the following front panel indicators:

(a) CONFLICT RED MONITOR – illuminated for the duration of a signal conflict or absence of a Red Signal.

(b) VOLTAGE MONITOR – illuminated for the duration of failure of any monitored voltage level.

(c) FAILURE STATUS INDICATORS – thirteen for the Type 12 Monitor and four for the Type 3 Monitor. One failure status indicator shall be labeled and assigned to each channel of the Monitor, and each shall be labeled and assigned to each channel of the Monitor, and each shall be illuminated when its respective channel is active (Green, Yellow, or Walk). The Failure Status Indicators shall indicate the active channels at the instant of the transfer of the output relay to the Conflict state and/or the channels detected as having an absence of RED signal output voltage. One indicator shall be illuminated whenever a conflict occurs due to absence of a Red Signal.

(13) Controls.
The MONITOR shall have the following front panel controls:

(a) Manual Reset (momentary contact push button)

(b) Minimum Flash Time:

0 Second Setting
4 to 10 Second Settings in 1 Second Increments.

(14) Over-Current Protection.
The MONITOR shall have a front panel-mounted over-current protection device in the 120 volt AC+ input to the unit. No internal fusing is acceptable.

(15) Monitor Type.
The two-phase controllers shall be supplied with a Type 3, three-channel programmable monitor. Three to eight phase controllers shall be supplied with a Type 12, twelve channel programmable monitor.

(16) Programming.
Programming of MONITOR UNIT shall be as follows:

(a) Type 3: The 3 channel unit with four inputs per channel. These 3 channels are preprogrammed for mutual noncompatibility.

(b) Type 12: The 12 channel unit with four inputs per channel. These 12 channels are programmable for the specific application.

(c) The fully programmable 12 channel MONITOR shall be programmed by the Contractor to comply with the sequence diagram shown on the Plans. Programming shall be accomplished by adding soldered wire jumpers to a universal, interchangeable PROGRAMMING CARD.

(17) Cabinet Interlock.
The MONITOR shall have two 92) terminals internally connected (#20 AWG Jumper) to indicate the presence of the MONITOR to the external circuitry. These terminals shall be identified as CABINET INTERLOCK A and CABINET INTERLOCK B.

(18) Red Monitor Enable.
Presence of AC+ at this input will enable the MONITOR unit to detect the absence of RED indications. Absence of AC+ will inhibit detection of the absence of RED indication.

(19) Minimum Flashing Indication After Power Interruption to the Controller Assembly.

(a) The MONITOR unit shall include a means of monitoring the absence of AC+ input to the unit. When the duration of power interruption exceeds 475 plus or minus 25 milliseconds, the MONITOR unit shall de-energize its output relay which normally results in transfer of the signals to FLASHING INDICATION. The de-energized state of the output relay shall be maintained for a timed interval following restoration of power to the AC+ input. The duration of this interval shall be adjustable between the limits of 4 seconds and 10 seconds with repeatability of 1 second and with maximum incremental adjustment of 1 second. There shall be a 0 second setting for use when minimum flashing time is not desired.

(b) Upon completion of the timing of this interval, the controller unit shall begin operation in its start-up (initialization) sequence and the signalization shall return to its normal operation.

(20) Start/Delay Control.

(a) The MONITOR unit shall include a means of monitoring the absence of AC+ input to the unit. When the duration of this power interruption exceeds 475 plus or minus 25 milliseconds, the unit shall de-energize its START/DELAY relay. The de-

energized state of this relay shall be maintained during the power outage and for 2 ½ plus or minus 1 seconds after restoration of power to the AC+ input.

(b) The START/DELAY relay shall consist of a Form C relay output contact. These relay contacts shall be capable of switching all loads in the range from 2 milliamperes at 18 volts DC to at least 3 amperes at 135 volts AC.

(21) Pin Assignments.
Input/output pin terminations of the MONITOR shall be as shown in Table 02890 – 8.

c. Flasher.
The cabinet shall be furnished with and wired for a jack-mounted 120VAC, single circuit, all solid –state flasher unit. The flasher shall have a duty cycle of 50 percent at a flash rate of 1 cycle per second. The flasher will be wired into the cabinet to provide optionally a yellow/red flash display or an all-red flash display. The flasher shall be rated at 25 amperes at 120 VAC. A heat sink shall be made part of the flasher body.

d. Railroad Preemptor.
The railroad preemptor equipment herein described shall be required for signalized intersections having one or more approaches across a nearby railroad right-of-way. The preemption sequence and display shall comply with the sequence chart shown on the Plans.

(1) Operation.
Operation of the preemptor unit shall begin with the closing of a normally open 120 VAC electric circuit, which remains closed during passage of railroad traffic. This switch circuit is remote to the preemptor unit and part of track detection equipment not covered by this contract. The field input from the track detector shall be protected against transient voltage or lightning by the installation of a 150 Volt RMS Varistor or equal across it to ground. Above ground potentials shall be employed to initiate preemption operation.

(2) Intervals.
All preemption intervals shall be adjustable from 0-20 seconds with plus or minus 0.1 second adjustment tolerance. All preemption timing shall be digital in nature and based on the 60 HZ line frequency. Interval settings shall be via rotary ten position thumbwheel switches with discrete positions for each increment of time as required on the controller.

(3) Housing.
The preemption unit shall be housed in a sturdy painted sheet metal case.

(4) Flash Interval.
In addition to the intervals necessary to provide the preemption required by the sequence chart, a MINIMUM FLASH interval with setting switch shall be provided which will time the minimum allowable duration of the flash or Dwell display. The Dwell display shall remain in effect for the minimum setting should the track call cease before that interval has timed out.

(5) Pins.
All electrical connections shall be made through on one or more “MS” type pin connectors meeting Military Specification MIL-C-26482. A wire harness of suitable length shall connect the “MS” connectors to the cabinet terminals.

TABLE 02890 – 8
PIN ASSIGNMENTS

Type 3 – Connector shall mate with MS 3116 20-41S

A. AC+1 (jumpered internally to AC+ II)
B. AC+II Input
C. Output Relay 1 Common
D. output Relay 1 Open
E. Output Relay 2 Common
F. Output Relay 2 Closed
G. Start/Delay Relay Common
H. Start/Delay Relay Open
J. Channel 3 Green
K. Channel 3 Yellow
L. Channel 2 Green
M. Channel 2 Yellow
N. Channel 1 Green
P. Channel 1 Yellow
R. Channel 1 Walk
S. +24 V Monitor II
T. Controller Voltage Monitor
U. +24 Spare Monitor I
V. Logic Ground
W. Chassis Ground
X. AC-
Y. Cabinet Interlock A
Z. Output Relay 1 Closed
a. Output Relay 2 Open
b. Start/Delay Relay Closed
c. Channel 3 Walk
d. Channel 3 Red
e. Channel 2 Walk
f. Channel 2 Red
g. Channel 1 Red
h. Reset
i. Red Enable
j. Red Enable
k. Spare 1
m. Cabinet Interlock B
n. Spare 2
p. Spare 3
q. Spare 4
r. Spare 5
s. Spare 6
t. Spare 7

Type 12 – Connector A shall mate with MS 3116 22-55 SZ

A. AC+ (jumpered internally to AC+ II)
B. Output Relay 1 Open
C. Output Relay 2 Closed
D. Channel 12 Green
E. Channel 11 Green
F. Channel 10 Green
G. Channel 9 Green
H. Channel 8 Green
J. Channel 7 Green
K. Channel 6 Green
L. Channel 5 Green
M. Channel 4 Green
N. Channel 3 Green
P. Channel 2 Green
R. Channel 1 Green
S. +24 Spare Monitor 1
T. Logic Ground
U. Chassis Ground
V. AC-
W. Output Relay 1 Common
X. Output Relay 2 Common
Y. Channel 12 Yellow
Z. Channel 11 Yellow
a. Channel 10 Walk
b. Channel 10 Yellow
c. Channel 9 Yellow
d. Channel 8 Yellow
e. Channel 7 Yellow
f. Channel 6 Yellow
g. Channel 5 Yellow
h. Channel 3 Yellow
i. Channel 3 Walk
j. Channel 2 Yellow
k. Channel 1 Yellow
m. Controller Voltage Monitor
n. +24 V Monitor Inhibit
p. Output Relay 1 Closed
q. Output Relay 2 Open
r. Channel 12 Walk
s. Channel 11 Walk
t. Channel 9 Walk
u. Channel 8 Walk
v. Channel 7 Walk
w. Channel 5 Walk
x. Channel 4 Walk
y. Channel 2 Walk
z. Channel 1 Walk
AA. Spare 1
BB. Reset
CC. Cabinet Interlock A
DD. Cabinet Interlock B
EE. Channel 6 Walk
FF. Channel 4 Walk
GG. Spare 2
HH. Spare 3

Type 12 – Connector 3 shall mate with MS 3116 16-26 S

A. AC+ II Input
P. Spare 1

B. Start/Delay Relay Common
C. Start/Delay Relay Open
D. Channel 12 Red
E. Channel 11 Red
F. Channel 9 Red
G. Channel 8 Red
H. Channel 7 Red
J. Channel 6 Red
K. Channel 5 Red
L. Channel 4 Red
M. Channel 2 Red
N. Channel 1 Red
R. +24 V Monitor II
S. Spare 2
T. Spare 3
U. Start/Delay relay Closed
V. Channel 10 Red
W. Spare 4
X. Spare 5
Y. Spare 6
Z. Channel 3 Red
a. Red Enable
b. Spare 7
c. Spare 8

C. Traffic Detector Amplifiers.

1. Inductive Loop Vehicle Amplifier.

a. Vehicle Amplifier.
Electronic circuitry shall employ all solid-state components, except for the output relay. Solid-state components shall use plug-in unit bases for easy removal, replacements, and insertions. All parts shall be identified by generic name or cross-indexed identification number on all printed circuit boards or mounting unit. If the proposed equipment includes manufacturer's parts identification numbers only, a cross index to generic identification shall be required.

(1) The amplifier shall be housed in a protective metal case with the total volume not exceeding 75 cubic inches, including power supply.

(2) An indicator light for visual evidence of each vehicle detected shall be furnished in the front panel.

(3) The amplifier shall be designed to operate with one or more sensors consisting of an inductive wire loop or loops buried in the traveled portion of the roadway.

(4) The amplifier shall have the capability to tune loop inductances from 20 microhenries to 700 microhenries without the use of external components, and the operating frequency shall not be crystal controlled.

(5) Physical orientation of the amplifier unit shall not affect the tuning or operation fo the amplifier.

(6) Detection of vehicles shall be positive for vehicle speeds from zero (continuous presence) to 80 miles per hour.

(7) The amplifier shall be of quality design and construction so that "CROSS TALK" interference between amplifiers resulting in false controller actuation shall not occur in systems with up to ten operating amplifiers. A minimum of two operating frequency modes shall be manually selectable.

(8) The amplifier shall be equipped with "Failsafe" circuitry which will cause the placement of a continuous vehicle call to the controller if the loop circuit becomes open, grounded, or shorted.

(9) Detection sensitivity shall be adequate to cause positive detection with a 0.02 percent change in loop inductance throughout a tuning range of 40 to 550 microhenries and with a 0.05 percent change in loop inductance at 20 and at 700 microhenries.

(10) Amplifier operation in the presence mode shall conform to front panel switch setting with "LONG", "MEDIUM", or "SHORT" duration selectable.

(11) A pulse mod shall be selectable via front mounted switch. In the pulse mode, a momentary detection between 50 milliseconds and 200 milliseconds in duration shall be registered when a vehicle enters the detection zone. Subsequent pulse detections shall be registered by other vehicles entering unoccupied portions of a loop or other loops connected tot eh same amplifier.

(12) The amplifier shall be furnished with a normally open and a normally closed relay contact output for traffic controller actuation.

(13) Each amplifier unit shall have complete field tuning instructions written in the English language and permanently affixed to the outside of the case.

(14) All field tuning and switching controls shall be on the front panel, and tuning shall be accomplished without the use of any external instrument or tools.

(15) The 115 volt input shall be suitably fused, and the fuse shall be replaceable without the use of tools.

(16) Line and loop inputs shall be internally protected against transients generated by lightning or switching surges: 1 KV @ 75 x 10^2 millijoules either polarity across loop terminals, loop to ground, power input, power input to ground. Loop terminals shall withstand 1 KW for 1 millisecond.

b. Electrical Connector and Cable.

(1) Each amplifier unit shall be furnished with a ten (10) pin M.S. male connector and cable. Terminal wiring shall comply with the following code:

Ten-Pin M.S. 3106B18-1S

Pin	Cable Color Code	Function
C.	Black	115 volt AC Line
A.	White	Line Neutral
H.	Green	Earth
B.	Yellow	Relay Common
F.	Blue	Relay N.O. Contact
D.	Gray	Loop
E.	Brown	Loop
G.	Red	Relay N.C. Contact
I.	---	Not Used
J.	---	Not Used

(2) Each amplifier unit shall be furnished with a wiring harness with mating M.S. connector. The cable shall be color coded, as above, with insulated spade connectors and shall be minimum 48 inches in length.

D. Traffic Detector Sensor Units.

1. Inductive Traffic Detection Loop in Saw Cut.

Inductive traffic detection loops shall consist of conductors embedded in the pavement to measure the inductance of passing vehicles. The loop detector conductors shall be stranded copper #14 AWG. The insulation shall be Type XHHW cross-linked polyethylene insulated, UL

listed and color coded as shown on the Plans. The conductors shall be placed in a saw cut which shall be sealed with sealant meeting the requirements of Paragraph 02890 2.03.B of this Specification Section.

2. Pedestrian Push Button Detectors.
The Pedestrian Push-Button Assembly for use with the controllers shall be actuated by pushing a neoprene surface area at least 1 inch in diameter. The internal button shall be of the spring return type and cause the closure of a set of internal contacts. The push button/contact assembly shall be screwed into a one-piece, Federal Yellow painted aluminum die cast, cylindrical housing suitable for mounting on a steel pole in conformance with the Plans. The push-button assembly shall be constructed and gasketed to prevent accidental shock and provide weatherproof and freeze-proof operation.

E. Traffic Detector Lead Wire.
A twisted traffic detector loaded wire shall be provided from the traffic detector sensor unit to the shielded cable as shown in the Design Standards and Plans. The traffic detector lead conductor shall be stranded copper #14 AWG. The insulation shall by Type XHHW cross-linked polyethylene insulated UL listed and color coded as shown on the Plans. The conductor shall be place in a saw cut as shown on the Plans and sealed with a sealant meeting the requirements of Paragraph 2.03.B of Specification Section 02890.

F. Sign and Signal Support Poles.

1. These Specifications apply to the manufacture of poles for the support of traffic signals and signs. The height of poles shaft dimensions, and wall thickness shall meet the design requirements and mounting height of traffic signals and signs as set forth in these Specifications and on the Plans. Bracket arm lengths are indicated on the Plans.

2. Steel poles shall be fabricated from best, hot rolled basic open hearth steel and shall have only one longitudinal electrically welded joint and no intermediate horizontal welds or joints. The shaft shall be longitudinally cold rolled to flatten the weld and increase the physical characteristics so that the metal will have a minimum yield strength of 55,000 psi.

3. The steel poles covered under these Specifications shall be tapered, upright circular steel with a uniformly tapered shaft and a round cross section. These poles shall be processed to a minimum yield stress of 55,000 psi. The pole wall thickness (gauge) and other specification data in Table 02890 – 9 and elsewhere in this specification shall relate to the characteristics of the completed pole after fabrication. Steel sign and signal poles shall hav a section modulus equal to or exceeding those in Table 02890 – 9.

TABLE 02890 – 9

MINIMUM SECTION MODULUS FOR STEEL POLES
(Inches^3)

12 Inch Base Diameter	13 Inch Base Diameter

Location	#0 Gauge	#3 Gauge	#7 Gauge	#0 Gauge	#3 Gauge	#7 Gauge
Base	32.6	26.5	19.3	38.5	31.3	22.8
20’	29.3	15.3	11.2	23.2	18.9	13.8
24’	16.4	13.4	9.8	20.6	16.8	12.3
28’	14.2	11.6	8.5	18.2	14.8	10.9
30’	13.2	10.8	7.9	17.0	13.9	10.2
32’	12.2	10.0	7.4	15.9	13.0	9.6

4. The materials used shall meet or exceed the standards of American Society of Testing and Materials and the Society of Automotive Engineers, as noted, and such standards shall be made a part of this specification. Poles shall be galvanized inside and outside to ASTM A 123.

5. All welding shall be performed by welders qualified in accordance with “American welding Society Standard Specifications for Welded Highway and Railway Bridges”. All welding shall be performed in the positions using the electrodes and procedures permitted under the qualification techniques.

6. All steel and cast iron components, hardware and threaded fasteners, except anchor bolts, shall be galvanized after fabrication in accordance with ASTM Designations A 123, or A 153 or A 385, as applicable.

a. Steel Strain Poles.

(1) Strain poles shall be galvanized steel wit a uniformly tapered shaft. All oles shall be complete with a removable cast aluminum top cover with stainless steel set screws for fastening cover to top of pole. A “J” hook wire support shall be located inside the pole near the top, and four 2 inch threaded pipe couplings shall be located on the outside near the top of the pole. Two “u” bolt spanwire clamps shall be furnished complete for each pole. The threaded bolt shall be 5/8 inch in diameter and shall be furnished with galvanized hexagon nuts. The clamps shall be sized to fit each tapered pole at a point 18 inches from the top. A 4 inch by 8 inch handhole with 11 gauge galvanized steel or aluminum cover shall be installed 18 inches above the base of anchor base poles. The handhole opening in the pole shall be fitted with a steel frame welded into place. The cover shall be furnished with two (2) ¼ inch stainless steel installation screws and a #35 stainless steel chain to leash the cover at the handhole. The handhole shall be oriented on the pole so that it is centered between two adjacent anchor bolt holes in the base. A ground lug for #6 AWG ground wire shall be provided inside each pole and accessible from the handhole.

(2) The pole and all of its component parts shall be designed to support traffic signals or signs of the type and number indicated on the plans, suspended from a spanwire assembly. The shaft shall be fabricated form material providing a minimum yield strength of 55,000 psi after fabrication.

(a) Anchor Base Poles.
Unless otherwise specified, all strain pole traffic signal or sign supports shall be anchor base poles designed for installation on concrete foundations. Anchor base poles shall be provided with a cast base or welded plate base. The base shall be fabricated from drop-forged or cast steel of sufficient cross-section to fully develop

the ultimate strength of the poles. The base shall be fastened to the pole by means of a welded connection and shall develop full strength of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting (at yield stress) the bending moment of the shaft at its yield strength stress. Four removable cast iron covers for the anchor bolts shall be provided with stainless steel attaching screws.

(b) Anchor Bolts.
High strength steel anchor bolts, each fitted with one regular hex nut and one heavy duty square nut, shall be furnished with anchor base type of poles. All nuts and not less than 10 inches of the threaded ends of anchor bolts shall be hot dipped galvanized in accordance with ASTM Designation A 153. The anchor bolts shall have a minimum yield strength of 55,000 psi and a minimum ultimate strength of 90,000 psi each. The anchor bolts shall be capable of resisting (at yield strength stress) the bending moment of the shaft at its yield strength stress.

(c) Embedded Poles.
All poles designed for direct ground installation shall be furnished with factory installed steel ground line sleeves, each sleeve two (2) feet long. The thickness of the ground line sleeve shall be minimum three-eights (3/8) inch and shall be factory welded all around the top outside and bottom outside five feet, four inches from the base end of the pole for standard six (6) feet embedment. A steel plate shall be furnished welded across the open butt end of the pole for partial bottom cover and pole bearing.

b. Mast Arm Supports.

(1) Mast Arm Poles.

(a) The mast arm poles shall be galvanized steel with a uniformly tapered shaft. The shaft shall be fitted with a removable pole cap, a J-hook wire support welded inside near the mast arm connection, a welded frame handhold opposite the mast arm (of like design and installation to the lower handhole), and a flange plate assembly to match that welded to the butt end of the mast arm.

(b) Mast arm poles shall have a cast anchor base or welded plate base of adequate strength, shape, and size secured to the lower end of the shaft. The base shall be fabricated from drop-forged or cast steel of sufficient cross-section to develop the ultimate strength of the pole. The base shall be fastened to the pole by means of a welded connection and shall develop the full strength of the bending moment of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper anchor bolts. The pole shall be provided with removable cast iron covers for anchor bolts complete with stainless steel attaching screws.

(c) A welded frame handhole, approximately 4” x 8” and located 18 inches above the base, shall be provided. A grounding lug for #6 AWG shall be welded to inside of pole at a point readily accessible from the handhole for wiring. An 11 gauge galvanized steel or aluminum cover with two (2) stainless steel installation screws with a #35 stainless steel chain to leash the cover to the handhole shall be provided.

(2) Mast Arms.

(a) Mast arms shall be fabricated in the same manner as the upright shafts and with the same physical characteristics. The mast arms shall meet the design requirements necessary to support rigidly mounted traffic signals and signs, as designated on the Plans. All arms shall include a removable cap at the tip, signal

attachment method of the type and number shown on the Plans, and a flange plate welded to the butt end to provide a rigid connection to the mast. The assembly shall be constructed so that all wiring can be concealed internally.

(b) Mast arms shall be connected to the upright pole at a height necessary to provide a minimum clearance of 15'-6" and a maximum clearance of 17'-6" under traffic signal heads. Minimum clearance for signs shall be 18 feet over the entire width of the roadway.

c. Pedestal Poles.

The pedestal poles shall consist of one upright pole with suitable base and any other accessories or hardware as required to make a complete installation.

All poles shall be made of one continuous piece from top of base connection for the entire height of the pole. The cross-section shall be cylindrical and uniformly tapered from butt to tip. The cross-section at the tip shall have a 4 ½ inch outside diameter.

Bases shall be round, octagonal, or square in shape and of an ornamental fabricated cast material of a transformer type base. A handhole shall be provided in the base or 18 inches above the base in the pole. Bases shall be furnished with four steel anchor bolts of sufficient size and length to securely anchor the base to the concrete footing.

(1) Aluminum Pedestal.

Aluminum pedestals shall be of uniform round cross-section of tabular tapered type construction fabricated from one full length sheet. The shaft shall be threaded so as to be securely screwed into the base. The pedestal shaft shall be fabricated from aluminum tubing 6063-T4, heat treated to T-6 temper after fabrication, and meeting ASTM Designation B 26-SF 70A-T6 specifications. The top opening of the base shall be threaded to receive the shaft.

(2) Steel Pedestal.

Steel pedestals shall be of uniform round cross-section and shall have a uniformly tapered shaft of tapered, upright circular steel. The shaft and base shall be threaded so as to be securely screwed together. The pedestal shaft shall be fabricated of cold rolled steel galvanized according to the Specifications of ASTM A 123.

d. Wood Pole Supports.

(1) Wood service poles and standards shall be of the class and length shown on the Plans and, unless otherwise specified, they shall meet the requirements of the following Specifications: Wood service poles and standards shall be of pentachlorophenol treated southern pine, shall be classified according to the latest American Standard Dimensions of Southern Pine Poles and shall meet the requirements of ASA 05.1 except as specified. Preservative treatment of this material shall be in accordance with the American Wood Preserver's Association's Manual of Recommended Practice, Standards C1 and C4.

(2) All material shall conform to ANSI 05.1, Section 4, except that species shall conform to Treatment Group C, steam conditioning of southern pine, only. Shape where sweep is in one plane and one direction only shall be limited to a deviation of one inch (1") for each ten feet (10') of length where measured in accordance with Section 4.0 of this Specification Section for one hundred percent (100%) of the poles in any shipment.

(3) The preservative shall be pentachlorophenol. The pentachlorophenol solution shall consist of pentachlorophenol meeting the requirements of AWPA Standard P8 dissolved in a suitable petroleum solvent in accordance with AWPA Standard P9, section 1, Heavy Petroleum Solvent, or Section 2, volatile Petroleum Solvent (LPG). The heavy petroleum solvent solution shall have a concentration of not less than five percent (5%) pentachlorophenol by weight when tested in accordance with AWPA Standard A5. The volatile petroleum solvent solution shall have a concentration of pentachlorophenol

sufficient to produce the specified retention as determined by assaying the treated wood.

(4) The pole treatment shall be by the Rueping empty cell process or full cell process. When a heavy petroleum solvent pentachlorophenol solution is used, the treating process shall be Rueping empty cell process in accordance with AWPA Standard C4, Section 2. When volatile petroleum solvent pentachlorophenol solution is used, the treating process shall be the full cell process in accordance with AWPA Standard C4, Section 2. The poles furnished under this specification shall be treated in charges with other material requiring more than a thirty-eight one hundredths (.38) pound treatment.

(5) The net retention of preservative shall be not less than .38 pounds of preservative, by lime-ignition assay, per cubic foot of material in accordance with AWPA Standard C4, Section 3.1. A minimum penetration of preservative shall be three inches (3") or ninety percent (90%) of sapwood in accordance with AWPA Standard C4, Section 3.2. Determination of penetration for all poles shall be in accordance with AWPA Standard CR, Section 3.212. The pounds of retention by assay shall be marked on the pole below the branded code letters required by this Specification.

G. Conduit.

1. Metal conduit and fittings shall be rigid heavy-walled, hot dipped galvanized steel and shall comply with the latest edition of Underwriters Laboratories' Standard UL 6, Federal Specification WW-C-581 and American Nation Standards Institute C 80.

2. Plastic conduit (PVC) shall be heavy-walled, extruded moisture and oil proof polyvinylchloride, corrosion resistant, with watertight joints and high impact strength. Conduit and fittings shall be in accordance with the NEMA TC-2 and WC-1094 Specifications, UL listed.

H. Pull Boxes.

Pull boxes shall be constructed of Class A concrete reinforced in accordance with the details as shown on the Plans or Design Standards. Reinforcement shall consist of steel wire fabric, 4" x 4" – No. 4/4 @ 85 lb./100 sq.ft. The cover shall have a roughened top surface. Notches shall be provided for removing the cover. The words "Traffic Signal" shall be inscribed on the top of the cover with letters 2 inches high and 1/8 inch in relief as indicated in the Design Standards.

I. Cables and Conductors.

Traffic signal conductors, power service drops, detector conductors, and shielded loop lead-in cable shall be stranded copper with insulation rated at 600 volts meeting IMSA Specification 19.1. The cable or conductors shall be suitable for use in conduit, duct, aerial, or direct burial installation. Color coding shall be in accordance with the Insulated Power Cable Engineers Association (IPCEA) Color Code Chart No. 2. The cable size shall be as required by the Plans or directed to be installed by the Owner. The Contractor may install larger cable than required without extra compensation.

1. Power Service Drops.

The wire from the service drop to the controller shall be two #6 AWG copper wire cables with each conductor color coded, insulated, and an outer jacket of PVC, UL listed.

2. Signal Cable.

All signal cable shall conform to the applicable IMSA Specification 19.1. Stranded cable, copper #14 AWG, color coded conductors shall be used for all signal cable throughout the entire length or as indicated in the Plans. The outer jacket shall be black.

3. Shielded Detector Cable.

Loop lead-in cable shall be stranded copper, two conductors twisted, #14 AWG with each conductor polyethylene insulated. The cable shall have an aluminum 100 percent polyester shield with a #16 AWG drain wire having a chrome vinyl jacket. The shield shall be outside the

conductors. The outer jacket shall be PVC. The cable shall be UL listed, Style 2106.

J. Signal Span Wire Assembly.

1. Signal Span Wire.
Span wire for suspending signal heads between pole supports shall be 9,196 pound minimum breaking strength, 7 strand, Class a, copper clad steel meeting the requirements of ASTM designation A 460.

2. Tetherwire.
Strand cable for tetherwires shall be ¼ inch Siemens-Martin grade unless otherwise noted on the Plans and shall meet the requirements of ASTM designation A 475 for zinc coated steel wire strand, 7 strand, Class A zinc coating.

3. Terminations.

a. All span terminations at poles shall be made with a spiral bite dead-end of the proper material and strand size to fit the guy span used. A galvanized steel thimble of the proper size shall be used between the eye bolt or other fastener and the dead-end. The dead-end material shall be of the same material as the terminating wire. This shall include but not be limited to tetherwires, down guys, strut (sidewalk) guys, signal spans, and overhead detector lead-in spans or messengers.

b. A 5/8 inch diameter by 12 inch length single strand angle type eye bolt with two (2) 2 inch square curved washers, lock washer, and square nut shall be used on wood poles as required by the Plans. When the proper angle and location fo the span wire eye bolt exist on a wood pole, as determined by the Owner, and oval eye nut of drop-forged steel may be used as shown in the Plans, fastened to the threaded end of span wire eye bolt in lieu of this added eye bolt. All components and hardware shall be galvanized in accordance with ASTM designation A 123 or A153.

K. Messenger Wire.
Strand cable for messenger wire use (other than span wire above) shall be of the diameter(s) indicated on the Plans and shall meet the requirements of ASTM designation A 475 for zinc coated steel wire strand, 7 strand, Class A zinc coating. Tetherwires and aerial loop detector lead-in support spans shall be ¼ inch Siemens-Martin grade unless otherwise noted on the Plans.

L. Guying Assembly.

1. All guying components and hardware shall be galvanized in accordance with ASTM designation A 123 or A 153. pole guy cable shall be 3/8 inch utility grade unless otherwise noted on the Plans.

2. Anchors for guys shall be of the pressed steel 4-way expanding fluke type or of the steel or malleable iron sliding plate type. The minimum unexpanded diameter shall be 8 inches, and the minimum expanded area shall be 110 square inches. Anchors shall be coated with a black asphalt paint.

3. Guy anchor rods shall be drop-forged galvanized steel, ¾ inch diameter and 7 foot minimum length, threaded, of the single thimble eye type, with a square anchor bolt nut.

4. Sidewalk guy fittings shall include 2 inch I.D. standard galvanized steel pipe of required length with a malleable iron pole plate and guy clamp. The pole plate shall be fastened to pole with 3/8 inch thru bolt and ½ inch lag screws. The lower portion of any guy shall be protected as shown in the Plans or Design Standards.

2.03 MISCELLANEOUS MATERIALS.

A. Paint.

1. General Requirements.
All metal parts, fittings, signal heads except polycarbonate type, posts, pedestals, standards, and cabinets shall be prepared and painted according to these Specifications, except new galvanized poles, aluminum pedestals, and galvanized or aluminum hardware shall not be painted.

2. Types of Paint.
Types of paint to be used shall be as follows:

a. Primer.

(1) Chromate aluminum oxide coating process – shall meet or exceed Government Specifications MIL-C-5541.

(2) Epan Oxide baking primer – shall meet or exceed Government Specifications TT-P-636.

(3) Zinc Chromate primer – shall meet or exceed Government Specifications P-753.

(4) Iron Oxide – shall meet or exceed Government Specifications TT-P-63.

b. Enamel.

(1) Gloss (yellow or green) - shall be a high gloss alkyd enamel for exterior use and shall meet or exceed Federal Specifications TTC-595 Gloss Yellow or Green No. 1310. Color shall be standard Traffic Signal Yellow or Green. Color chips shall be furnished upon request.

(2) Lusterless (Black) – shall be lusterless over baked black enamel meeting or exceeding Federal Specifications TT-E-489.

(3) Alkyd Area Black Synthetic Baking Enamel with minimum gloss reflectance and shall meet or exceed the performance requirements of MIL-E-5557 Enamel Heat Resisting Glyceryl Phthalic, Type 4, Instrument Black.

(4) Aluminum Zinc Rust-Inhibitive – shall meet or exceed Federal Specifications TT-P-1561A.

3. Substitutions.
These specifications are not intended to specifically prohibit the use of paints or similar character but different composition or the use of polycarbonate signal heads and mounting brackets of equal end product color. Substitute products must be equivalent to specified paints for all qualitative requirements applicable to their use. Substitute products must be approved by the Owner before application; however, approval of a product shall not relieve the Contractor of his obligations outlined in these Specifications.

B. Inductive Loop Saw Cut Sealant.

1. Sawcuts for loops installed as shown on the Plans shall be sealed with an approved two-part embedding sealant manufactured specifically for embedding electrical wire or cable in concrete or bituminous pavement to be mixed with sand as recommended by the manufacturer, and meeting the following:

Sp. Gr. A/B/Mix	1.0-1.2 (A) 0.97-1.0 (B) 1.03-1.05 (Mix)
Viscosity (CPS) @ 77^0F A	800
Viscosity (CPS) @ 77^0F B	1,500
Viscosity (CPS) @ 77^0F Mix	1,200
Mix Ration (by volume)	1:1 + 2 Sand
Pot Life (1/2 gal. @ 77^0F)	13 minutes
Cure Time @ 77^0F	No tackiness after 1 hour
Hardness (Shore D)	55-65
Tensile Elongation	Greater than 100%
Water Absorption (one day)	0.20%
Salt Water (3%) Absorption	0.20%
Oil Absorption	0.03%
Gasoline Absorption	1.00%
Volume Resistivity (77^0F / 150^0F)	$5.1x10^{13}$OHM-CM/$2.0x10^{10}$OHM-CM
Tensile Bond Strength to Concrete @ 70^0F	350 psi
Shear Bond Strength to Concrete @70^0F	1,500 psi

2. Other sealants manufactured for embedding electrical wire or cable in bituminous or concrete pavement shall not be used unless approved by the Owner.

2.04 CONSTRUCTION EQUIPMENT.
All construction equipment required for the satisfactory performance of this work shall be on hand and approved by the Owner before execution of the work will be permitted to begin.

PART 3 - CONSTRUCTION REQUIREMENTS

3.01 GENERAL REQUIREMENTS.
All construction and equipment installations shall comply with the requirements provided herein and with the details shown on the Plans for the type work involved. Responsibilities of the Owner and Contractor are defined in Division 0 (Bidding and Contract Requirements) and Division 1 (General Requirements) of this City of Memphis Standard Construction Specifications.

A. Electrical Installations.

1. All electrical installations shall comply with all laws , codes, and regulations of the City of Memphis and with the service rules of the Memphis Light, Gas, and Water Division. Also, where not in conflict with such laws, codes, regulations, and rules, the electrical work shall comply with the requirements of the ANSI C-2.

2. All metallic conduit and the installed electrical equipment shall be grounded in accordance with the NEC, these Specifications, and the Plans. The effectiveness of the grounding shall be determined by measuring the resistance from the point of attachment of the grounding wire to the equipment or conduit to a convenient underground water line with an approved 0 to 50 ohm megger. Where a water line is not available, an auxiliary ground test method approved by the NEC shall be used with the required resistance reading.

B. Bonding And Grounding.

1. All metallic cable sheaths, cable shield, conduit (both metal and PVC), transformer cases, span wires, cabinets, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded. Grounding of conduit and neutral shall be accomplished as required under the NEC, except that grounding conductors shall be #6 AWG or approved equal, as shown in the Plans and Design Standards. Exposed

grounding conductors shall be enclosed in ½ inch diameter rigid galvanized steel conduit riser and shall be bonded to the ground rod with a copper clad ground clamp.

2. Bonding and grounding jumpers shall be 310 AWG solid copper wire with green insulation. Grounding conductors which ground electrodes to the signal system or the utility system neutral shall be bare stranded or braided copper wire of not less than the same cross-sectional areas a s #6 AWG. Ground electrodes shall be one-piece lengths of copper weld ground rod not less than 8 feet in length and 5/8 inch in diameter, installed in accordance with the NEC and Plans or design Standards.

C. Excavation, Construction, and Improvements.

1. The excavations required for the installation of conduit, foundations, and other items shall be coordinated with other improvements and performed in such a manner as to cause the least possible damage to the existing streets, sidewalks, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical equipment and foundations. Excavating shall not be performed until immediately before installation of conduit and other items. The material from the excavation shall be placed in a position where the least disruption and obstruction to vehicular and pedestrian traffic will be realized and the least interference with the surface drainage will occur.

2. The excavations shall be backfilled and compacted to at least the density of the surrounding material. All surplus excavation material shall be removed and disposed of by the Contractor outside of the highway right-of-way, in accordance with the provisions of Sections 02315, 02330, and 02335 of these Specifications, or as directed by the Owner.

3. Excavations, after backfilling, shall be kept well filled and maintained in a smooth and well drained condition until permanent repairs can be made. At the end of each day's work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from the portion of the roadway to be used by public traffic.

4. Excavation in the street or highway shall be performed in such a manner that not more than one traffic lane shall be restricted in either direction at anytime. Traffic signal installation work shall be scheduled so no part of the roadway is closed to traffic between the hours of 7-9 a.m. and 4-6 p.m., Monday through Friday unless approved otherwise by the Owner. Construction signing shall be incorporated in accordance with the provisions of Section 01551 of these Specifications.

D. Replacing Removed, Broken, Or Damaged Improvements.

1. Improvements such as sidewalks, driveways, curbs, gutters, portland cement concrete and asphalt concrete pavement, bituminous surfacing, base material, and any other improvements removed, broken, or damaged by the Contractor and not a part of the installation shall be replaced or reconstructed in kind according to the requirements of these Specifications without cost to the City of Memphis.

2. Whenever a part of a square of slab of existing concrete sidewalk or driveway is broken or damaged, the entire square or slab shall be removed and reconstructed as specified above.

E. Concrete Placement.

Concrete operations (foundations, sidewalks, curb, and gutter, and pavement) will not be permitted when in the opinion of the Owner the weather or other conditions are in any way unsuitable. Concrete placement and curing shall conform to the requirements of applicable Sections of these Specifications and Paragraph 3.02 F of this Section. Any concrete damaged by the weather or otherwise unacceptable to the Owner shall be removed and replaced without additional compensation.

F. Removal, Relocation, And Installation Of Traffic Control Facilities.

1. New controllers and associated equipment shall be timed per the signal timing sheets provided by the City of Memphis. Signal timing shall be requested a minimum of ten (10) days prior to actual signal turn on. The actual setting of the dials on the traffic signal controller and all associated equipment is to be accomplished by the Contractor or his representative.

2. All new signals installed at previously unsignalized locations are required to flash for a period of 24 hours before being placed in stop and go operation. Such new signals shall not be placed in the flash operation on a Thursday, Friday, or the day immediately proceeding a holiday.

3. New span mounted signal heads shall have a clearance to the roadway crown as required by the Design Standards. The span wire shall be fastened to the pole as shown in the Design Standards. Span wires shall maintain a sag of not more than five percent after being fully loaded with signal heads, cable, and lashing rods.

4. New pedestrian and vehicular signals will be hooded with tied canvas or opaque plastic bags until all work at the intersection has been completed, accepted by the Owner, and the signals are being turned on for traffic use. Hooded shall mean that the entire signal head shall be covered. At the time of turn-on of the new signal, any previously used signal taken out of service shall be hooded with tied canvas or opaque plastic bags or immediately removed.

5. Existing traffic control signs pertaining to turn or entry prohibition shall be relocated by the Contractor, as directed by the Owner, to appropriate positions on relocated existing supports or on the new poles using new stainless steel straps, as required, and without damage to the finish coating of the poles. At intersections where stop signs are replaced by traffic signals, once the signals are in use the stop signs will be removed immediately and returned to the City of Memphis.

6. Utility companies will be responsible for the relocation and/or removal of their poles and equipment. The poles and equipment to be removed by the Contractor have been generally noted on the Plans; however, it is the intent of the Contract to have the Contractor remove any City owned traffic control related or lighting equipment that is in conflict with the installation of the proposed equipment. All poles and equipment so designated or directed to be removed, including embedded poles, shall be removed in such a manner that the removed poles or equipment will not be damaged. Poles shall be cleaned of any concrete foundation material. Any damage due to negligence on the part of the Contractor because of lack of proper care of equipment shall be cause for the Owner to order its replacement. The cost of such replacement shall be borne fully by the Contractor without extra compensation.

7. Removed equipment or materials shall not be reused by the Contractor unless specifically noted on the Plans or ordered by the Owner. The Contractor shall remove, transport, and place the removed equipment in storage at a facility designated by the Owner, and all costs incidental thereto shall not be paid for separately but shall be included in the bid price for related items of work. The removed items remain the property of the City of Memphis and a receipt shall be obtained from the City on delivery.

G. Power Supply.

The Memphis Light, Gas & Water Division (MLGW) will provide an electrical secondary service drop for each cabinet. The Contractor shall coordinate with MLG&W for the service drop and make the connection from the drop to the cabinet panel terminal as specified herein.

H. Placing Signal In Service.

Following completion of all construction required by the Plans and Specifications and all tests, checks, and inspections are satisfied, the City will place the signal in service. The Contractor shall be present when the signal is placed in service.

I. Maintenance Of Traffic.

1. Traffic disruption and delay shall be kept to a minimum, and traffic operations shall be maintained through the project area for the length of the Contract in accordance with Section 01140 of these Specifications. The Owner may direct special efforts during certain phases of work to insure compliance with the approved construction schedule. The waiver of restriction, or the imposition of additional restrictions in critical areas or work and traffic flow, may be granted or established by the City.

2. The Contractor shall be responsible for providing and maintaining adequate safety lights and barricades to protect the public and must maintain access to abutting property. Such protective work shall be done inconformity with applicable portions of Section 01551 of these Specifications.

3. The Contractor shall be required to have police personnel present to direct traffic during signal turn-on if so directed by the Owner.

3.02 INSTALLATION OF TRAFFIC CONTROL EQUIPMENT AND MATERIALS.

A. Signal Heads.

The Contractor shall install the signal heads as required by the Plans in accordance with the Design Standards. The Contractor shall wire all signal heads complete for operation in accordance with the Plans, and shall provide a complete circuit from the signal head terminal, to the controller cabinet terminal. Labels shall be attached to the controller terminal identifying all signal functions. All signal field circuits shall be tested for continuity, “flashed out” to verify identification, and measured for amperage load with an approved clamp-on ammeter.

B. Traffic Signal Controllers.

1. The Contractor shall install the controller cabinet as required by the Plans, Design Standards, and Specifications, providing all other miscellaneous installation materials including grounding wire, copper clad grounding rod, secondary service drop, brackets and banding (if required), and foundations with anchor bolts, nuts, and washers (if required). The controller cabinet shall be completely wired for service.

2. Following the Field Tests indicated in Paragraph 4.03 of this Specification Section, the Contractor will install the controller and the terminal blocks in the cabinet. The Contractor will also install the detector amplifiers, flasher, monitor, load switches, and make the necessary wiring connections to the terminal blocks.

3. Foundations (if required) and topping shall be poured monolithically according to the requirements of Paragraph 3.02.F of this Specification Section. Anchor bolts and reinforcing steel shall be placed in accordance with the Plans and Design Standards. The bottom shall rest on firm, undisturbed ground and the top shall be formed to present a neat appearance.

C. Traffic Detector Amplifiers.

1. Inductive Loop Vehicle Detectors.

The Contractor shall install embedded vehicle loops and leads, shielded loop lead-in cable, and amplifiers according to these Specifications. All detector loops and lead-in cables shall be tested before and after they are sealed in the pavement to assure that there are no shorts to ground in the system and that loop plus lead-in inductance is within the operating range of the detector in accordance with the Design Standards.

a. Vehicle Loops and Leads.

Vehicle loops and leads shall be installed according to Paragraphs 3.02 D and 3.02 E of this

Specification Section.

b. Shielded Loop Lead-In Cable.
Shielded loop lead-in cable shall be installed according to Paragraph 3.02 I of this Specification Section.

c. Inductive Loop Vehicle Amplifier.
The Contractor shall install the amplifier in the Controller Cabinet and shall make the necessary connections between the controller and terminal blocks in the cabinet and the amplifier to render the detector system operational.

D. Traffic Detector Sensor Units.

1. Inductive Traffic Detection Loops.
The detector loop saw cuts shall be made with appropriated pavement saw and cooling lubricant. The width and depth shall be as required in the Design Standards or Plans. Before placement of the wire, the saw cut shall be cleaned and dried with compressed oil free air. Inductive traffic detection loops shall be installed as required in the Design Standards (T/S6).

2. Pedestrian Push Buttons.
The Contractor shall install pedestrian bush buttons according to the pole locations and orientation shown in the Plans. The push buttons shall be wired to the controller in accordance with the Plans. The pedestrian actuated signal sign given in the Plans shall be installed on the pole with each push button.

E. Traffic Detector Lead Wire.
The detector loop lead saw cuts shall be made with the appropriate pavement saw and cooling lubricant. The width and depth shall be as required in the Plans. Before placement of the wire, the saw cut shall be cleaned and dried with compressed oil free air. Traffic detector lead wire shall be installed as required in the Design Standards (T/S 6). The loop lead wire from the loop to the splice with the shielded loop lead-in cable in the pull boxes, conduits, or pole base or the terminal in the controller cabinet shall be twisted in accordance with the Plans and Design Standards.

F. Sign And Signal Support Poles.

1. Foundations.

a. Foundations for posts, standards, and pedestals, shall be Class A portland cement concrete as specified in Section 03050 of these Specifications. Anchor bolts, conduits, and reinforcing steel shall be placed in accordance with the Plans and Design Standards.

b. Foundations for posts, standards, and pedestals shall be poured monolithically to final grade. The exposed portions shall be formed to present a neat appearance. The bottom of concrete foundations shall rest on firm, undisturbed ground. A vibrator shall be used in the pouring of all foundations to remove voids and air entrapment.

c. Forms shall be true to line and grade. Tops of foundations for posts and standards, except special foundations, shall be finished at sidewalk grade or as ordered by the Owner. The tops of foundations shall be 6 inches deep and square, with the dimension equal to the diameter of the foundation. A 1 inch joint material shall be placed around the 6 inch top square. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position and to proper height and shall be held in place by means of a template until the concrete sets. Conduit entries in addition to those required for the installation shall be placed in each foundation, oriented as shown on the Plans or as directed by the Owner, and capped according to these Specifications. Calcium chloride shall not be used to speed the setting of the concrete.

d. Both forms and ground that will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly cured for at least 12 hours and hardened sufficiently to allow form removal without causing damage to the concrete. No pole shall be installed until eight (8) days after the foundation has been poured.

e. Ordinary surface finish shall be applied to exposed surfaces of concrete. Wherever the edge of a concrete foundation or sidewalk section is within 18 inches of any existing concrete improvement, the sidewalk section shall be extended to meet said existing improvement.

f. Where obstructions prevent construction of planned foundations, the Contractor shall construct a foundation satisfactory to the Owner.

2. Installation Of Poles.

Wood poles, where required, shall be set to the depth shown in the Design Standards or the Plans and with a 30 inch by 12 inch by 3 inch treated crib board and anchor key perpendicular to the resultant vector of the applied strain(s). Steel poles shall be bolted as shown in the design Standards or the Plans or embedded in a 6 inch concrete envelope. Poles shall be fitted with all necessary hardware to make the installation complete. Steel poles shall be oriented such that the handholes are facing away from the street and oncoming traffic in the near curbs at approximately 90^0 or more from the curbs, unless otherwise directed by the Owner.

3. Plumbing of Poles.

Plumbing of standards, posts, and pedestals shall be accomplished by adjusting the nuts. Shims or similar devices for plumbing or raking will not be permitted. After plumbing or raking has been completed, anchor bolts will be cut off ¼ inch above the top nut and the exposed surface painted with rust protective paint. Caps shall be placed over the nuts and a cement grout placed under the pole with a weep hole – all as shown on the Plans.

4. Cable Hangers.

All cables and conductors running in a pole which enter or leave the pole through a weatherhead, mast arm, signal head, push button, or controller cabinet assembly shall be hung with a strain relief hanger-gripper from the J-hook in the top of the pole before leaving or after entering the pole. Cable(s) entering or leaving via the pole foundation shall be hung in a strain relief hanger-gripper if the cable (s) rises more than 8 feet above the foundation. The cables and conductors shall be in one or more hanger-grippers with the gripper distributing the weight over a minimum of one foot.

5. Entry Bushings.

All entry or exit points through field drilled holes in poles, pedestals, or mast arms at the point of attachment of vehicle or pedestrian heads shall be tapped and shall have a threaded PVC stub extending two (2) inches beyond the outside surface to protect the cable and conductors from sharp edges or corners and to maintain cable alignment in conformance with the Plans.

G. Conduit

1. Trenched Underground Conduit.

a. Threads on metal conduits shall be clean cut, straight, and true and of sufficient length to permit proper coupling; long running threads will not be permitted on any part of the work. Threads shall be protected in transit and during installation, and conduit shall be provided with proper supports and protection during construction to prevent damage to the threads. All ends of pipe installed for future connections shall be properly threaded, reamed, and capped to prevent water and foreign matter from entering the conduit system. Sections shall be made up with pipe dope so that ends of conduit will abut. Threaded ends in pull boxes and foundations shall be provided with approved conduit bushings. All joints shall be sealed with

pipe dope for a waterproof installation.

b. All bens into pullboxes and foundations shall be free from kinks and of such easy curvature to permit the drawing in of cables without damage to insulation. Conduit between pull boxes, foundations, and poles shall be placed in a straight line, unless otherwise shown in the Plans.

c. After installation of the conduit is completed, all conduit shall be tested with a mandrel according to the requirements of Paragraph 4.02 of these Specifications. After the mandrel test, all conduit shall be scoured with a stiff wire brush slightly larger in diameter than the conduit. The Contractor shall clear all conduit in the presence of the Owner.

d. All conductors, except sawed loop detector conductors and span wire runs (as shown on the Plans), shall be run in conduit except where the run is inside poles. Where signal conductors are run in standards containing high voltage (over 600 volts) street lighting conductors, the lighting conductors shall be disconnected and encased in flexible metal or rigid metal conduit.

e. Conduit shall be laid to a depth of not less than 36 inches below pavement grade unless otherwise approved by the Owner, except conduit may be laid at a depth of not less than 24 inches below top of curb when placed back of the curb. Conduit runs shall be located as shown on the Plans or as directed otherwise by the Owner.

f. Conduit sizes will be indicated on the Plans. Signal conduit shall be a minimum of 2 inches in diameter and detector conduit a minimum of 1 inch in diameter, unless otherwise indicated. Conduit for service connections shall be 2 inches in diameter. Conduits smaller than 1 inch diameter shall not be used unless otherwise specified, except grounding conductors at service points shall be enclosed in ¾ inch diameter PVC conduit. The Contractor may, at his own expense, use larger size conduit than specified, in which case it shall be for the entire length of the run with no reducing couplings permitted.

g. Conduit terminating in anchor base standards and pedestals shall extend approximately 6 inches above the foundation and shall be sloped toward the handhole opening. Conduit shall enter concrete pull boxes from the bottom and shall terminate not less than 2 inches nor more than 4 inches above the bottom of the box and near the box walls to leave the major portion of the box clear. All such metal conduit terminations shall be fitted with a grounding bushing to protect the cable jackets and to bond the conduits into the ground system in accordance with the plans.

h. Existing underground conduit to be incorporated into a new system shall be checked with a mandrel and scoured the same as new conduit, all in the presence of the Owner.

i. An approved rope or snaking device shall be placed in all conduit (new and reused) following mandrel check and scouring for use in pulling in pull ropes for installing the wiring cable or conductors. A 2 inch mandrel ½ inch smaller in diameter than the conduit shall be passed through the entire length of the conduit immediately before installation of cable.

2. Jacked Underground Conduit.

Conduit under existing pavement shall be placed by an approved jacking or drilling method. Existing pavement shall not be disturbed unless otherwise directed by the Plans or by the Owner.

3. Conduit Risers.

Conduit risers shall be fitted with condulets and a weatherhead, and attached to the poles as shown on the Plans or Design Standards.

H. Pull Boxes.

1. Pull boxes shall be installed at locations shown on the Plans or where directed by the Owner. Covers shall be flush with the curb or sidewalk grade or with the surrounding ground, as required. No pull boxes shall be placed in the roadway area.

2. Electrical conductors shall be placed within pull boxes in such a manner as to be clear of any metal frame and the cover. Ground rods shall be placed in the pull boxes where required in accordance with the Plans and Design Standards.

3. The bottom of the pull box shall rest firmly on a bed of crushed limestone with a minimum depth of 12 inches below the bottom and extending 6 inches beyond the outside edge of the pull box, unless otherwise specified by the Owner.

I. Cables And Conductors

All cables and conductors shall be installed according to these Specifications.

1. General Requirements.

a. Cable Pulling in Conduit.

All cables and conductors shall be pulled into conduit using ropes or pull lines with pull wheels, making the pull parallel to the conduit opening. Pulling shall be by hand with pulling compound for lubricant approved by the Owner. No power or mechanical puller shall be used. A cable grip to distribute the pulling force over a minimum of 1 ½ feet of the cable shall be used . All cable and conductor in any section of conduit shall be pulled as one bundle. The pull force in pounds shall not exceed 0.008 times the summation of the mil cross-section area of the conductor wires being pulled. The insulation on the cables and conductors shall not be used in calculating the pull force.

b. Cables Attached to Spans.

Cables shall be attached to span or messenger wire by means of copper clad spiral lashing rods of the proper size for the cable being attached. Lashing rods shall be installed end to end.

c. Wiring Terminations.

All field wiring shall be attached in the controller cabinet to the terminals and labeled as to function of each cable and conductor, conforming to the Plans. The Contractor shall attach the electrical service lead.

All wiring ends to be terminated on terminal blocks in the controller cabinets, signal heads, or elsewhere shall be fitted with a crimp-on, vinyl insulated spade wire terminal of the proper size.

2. Power Service Drops.

The Memphis, Light, Gas & Water Division (MLG&W) will provide an electrical secondary service drop for each cabinet. These drops will be overhead or into the cabinet if source is underground. The Contractor shall coordinate with MLG&W for the service drop and make the connection from the drop to the cabinet panel terminal. The MLG&W service drops will be a two-conductor No. 6 aluminum cable. The Contractor shall splice to the drop as required to a two-conductor #6 AWG copper cable using a plated split-bolt connector with spacer for joining copper to aluminum. The splice shall be covered and weatherproofed using electrical tape forming an insulation equal or greater than the connecting cables. The Contractor will bring the overhead droop into the cabinet through the conduit and signal pole system shown on the Plans. Under ground power service shall be coordinated with MLG&W with power service provided in a pole or cabinet foundation. The power supply connection shall be made to a 30 ampere circuit breaker mounted in the cabinet separate from the signal terminal panel. A power outlet with a duplex outlet receptacle with U-type ground slot shall be provided in the cabinet.

3. Signal Cable.
All splices in the signal wiring shall be made with solderless connectors of a copper sleeve compressed type, crimped with a suitable crimping tool, and covered with a screw-on, removable, reusable plastic cap. All splices shall be made in the pole bases and condulet. A cover kit shall be placed over splices as shown in the Plans or when directed by the Owner.

4. Shielded Loop Lead-In Cable.
All splices between Loop Detector Leads and Shielded Loop Lead-In Cable shall be soldered with resin core electrical component material. The soldering unit shall have a heating capability for use with #12 AWG wire connections. A heat sink device shall be used when making the solder joint. The soldered joint shall be covered with a screw-on, removable, reusable plastic cap. After installation of the splice cap, the cap shall be thoroughly filled with an electrical grade fast-drying sealing compound. The splice shall then be held inverted until the compound sets. Splices shall be made in the pole bases, condulet, or pull boxes.

J. Signal Span Wire Assembly.
The signal span wire assemblies shall be installed by the Contractor in accordance with the Plans and Design Standards.

K. Messenger Wire.
Messenger wire shall be installed by the Contractor in accordance with the Plans and Design Standards.

L. Guy Assembly.
Guy assemblies shall be installed by the Contractor in accordance with the Plans and Design Standards.

3.03 PREPARATION OF TRAFFIC CONTROL EQUIPMENT.

A. Painting.

1. General.
In general, the following materials and equipment require finishing:

a. New signal heads except plastic composition type, terminal compartments and framework, push-button housing, cabinets 9except aluminum), and guard parts shall be painted.

b. New standards, posts, and pedestals shall be painted unless they are galvanized or aluminum or unless otherwise specified on the Plans.

c. Existing equipment and materials to be relocated and existing equipment altered in place shall be repainted, unless otherwise specified or approved.

2. New Equipment.
The preparation and finishing of new equipment shall be as follows:

a. Standards, posts, pedestals, and any other galvanized surface to be painted shall be cleaned and coated with the approved primer best suited for the surface.

b. If an approved prime coat has been applied by the manufacturer and is in good condition, additional primer application by the Contractor, other than for repairs, will not be required.

c. When specified to be painted, standards and posts shall have at least two coats of Traffic Paint applied as follows:

(1) Mast arms and standards with bracket mounted signals shall be painted in their entirety, except that polycarbonate signals and brackets shall be omitted and only the standards painted.

(2) Pedestrian push-button posts, steel pedestals for cabinets, and standards with top mounted signals, including left turn signals, shall be painted from the base to the top of the post.

d. Steel controller cabinets shall have a finish on all surfaces, both interior and exterior, consisting of a minimum of one coat of zinc chromate primer on all surfaces and two coats of a high grade aluminum paint, unless otherwise shown on the Plans.

e. All signal heads, signal head mountings, and pedestrian push-button housings shall have one or more coats of primer followed by two coats of Traffic Signal Yellow except polycarbonate type which shall present the equivalent color.

f. Louvers as specified, interior and exterior of signal hood, and fronts and backs of back plates shall have one or more coats of primer followed by two coats of Lusterless Black enamel, except polycarbonate type. All factory enameled equipment and materials shall be examined for damaged paint after installation, and such damaged surfaces shall be repainted to the satisfaction of the Owner. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

3. Existing Equipment And Materials.

a. Existing equipment and materials to be repainted, whether remaining in place or to be relocated, shall be cleaned of all rust, scale, grease, dirt, and poorly bonded paint by any method satisfactory to the Owner. Immediately after cleaning, all bare metal shall be primed as appropriate, or as specified for new material. A finish coat shall then be applied over newly primed areas followed by one or more finishing coats over the entire surface.

b. Blast cleaning of galvanized metal surfaces in good condition, as determined by the Owner, will not be permitted.

4. Painting Procedures.

a. All paint coats may be applied either by hand brushing or by approved spraying machines in the hands of skilled operators, except that no spraying shall be done at the job site. The work shall be done in a neat and skillful manner, and the Owner reserves the right to require the use of brushes for the application of paint should the work done by the paint spraying machine prove unsatisfactory or objectionable, as determined by the Owner.

b. The thickness of each paint coat shall be limited to that which will result in uniform drying throughout the film. Skips, thin areas, or other deficiencies in any one coat of paint shall be corrected to the satisfaction of the Owner before succeeding coat is applied.

c. The final coat shall present a smooth surface, uniform in color, free of runs, sags, or excessive brush marks.

PART 4 – TEST, SEVICE CHECKS, INSPECTION, AND DOCUMENTATION

4.01 GENERAL.

The Contractor shall be responsible for the installation tests, demonstration of the functioning system, and checks of all hardware.

4.02 CONDUIT TESTS.

After installation of the conduit is completed, all conduit installed shall be tested with a mandrel having a diameter ½ inch smaller than the conduit and a length of 2 inches. All conduit which will not allow passage of the mandrel shall be repaired to the satisfaction of the Owner; if repairs cannot be made, the conduit shall be remove and replaced at no additional cost to the City. After the mandrel test, all conduit shall be scoured with a stiff wire brush slightly larger in diameter than the conduit. The Contractor shall clear all conduit in the presence of the Owner.

4.03 FIELD TESTS.

Prior to completion of the work, the Contractor shall cause the following tests to be made on all traffic signal circuits in the presence of the Owner. Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Owner, and the same test shall be repeated until no fault appears.

A. Ground Test.

Each circuit shall be tested for grounds in the circuit.

B. Megger Test.

A megger test shall be made on each circuit between the circuit and ground. The insulation resistance shall be not less than the values specified in Section 119 of the NEC. The load in amperes of each signal circuit shall be measured at the controller cabinet with a clamp-on ammeter. If the amperage is in excess of the expected lamp load plus minimal transmission losses, the circuit will not be accepted and shall be replaced or corrected by the Contractor at no additional compensation.

C. Functional Test.

A functional test shall be performed in which it is demonstrated that each and every part of the system functions as specified or intended herein. Signal circuits shall be “flashed out” from the cabinet terminals to determine that the proper function has been assigned each circuit.

D. Detector Ground Test.

All detector loops and leads shall be tested before and after they are sealed in the pavement to be sure there are no shorts to ground in the system and to assure that the loop plus lead-in inductance is within the operating range of the detector, all according to the Standards on loop installation.

4.04 INSPECTION.

All work and materials to be performed or furnished under these specifications shall be subject to observation and inspection by the Owner according to Section 00710 (General Conditions) of the Contract Document. Request for an Owner Inspector in connection with work under these Specifications shall be made by the Contractor at least twenty-four (24) hours before the services thereof will be required.

4.05 MILL TEST REPORTS AND CERTIFICATION.

Mill Test Reports or Certifications of Specifications for Materials and Design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the materials:

A. “Mill Test Reports” (M.T.R.) for MAJOR structural items only, as noted in Table 02890-10, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during the fabrication, M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.

B. Certification of conformance to the Specifications for all remaining material not covered by M.T.R. as noted in Table 02890-10.

C. Certification that all welding was performed by operators qualified as follows: Steel welders to AWS and aluminum welders to ASME.

D. Certification of conformance to the Specification for the design of all components not completely dimensioned and detailed in the Design Standards.

TABLE 02890-10

MILL TEST REPORT AND CERTIFICATION OF CONFORMANCE REQUIREMENTS

Component Materials	M.T.R.	Certification
Tubes for arms and poles	X	
Base castings	X	
Anchor Bolts	X	
Pole tops, misc. fittings and hardware		X
Fabricated or cast type arm connections		X
Galvanizing		X
Signal cable and wire		X
Loop Sealant		X
Concrete	X	

4.06 "AS-BUILT" PLANS FOR TRAFFIC SIGNAL INSTALLATIONS.
Upon completion of the work, and prior to final inspection and acceptance, the Contractor shall submit to the Owner two (2) copies of "As-Built" or corrected plans on mylar or linen showing in detail all construction changes, including location and depth of conduit. The Contractor shall also furnish all literature and drawings which are received with the equipment to be installed and which pertain to the engineering installation, operation, warranty, and maintenance of that equipment.

4.07 DOCUMENTATION.
The Contractor shall furnish to the Owner one set of the documentation described in Paragraph 2.02.B.1.d of this Specification Section for each traffic signal controller / cabinet installed.

4.08 GUARANTEE.
The traffic Signal System(s) installed under these Specifications, including all equipment, parts, and appurtenances in connection therewith shall be guaranteed to the City by the Contractor according to the requirements of Section 00710 (General Conditions) of the Contract Documents. Upon completion of the project, warranties or guaranties on equipment and materials that are offered by the manufacturers as normal trade practice and have not expired shall be turned over by the Contractor to the Owner.

PART 5 – MEASUREMENT.

Each accepted installed item relating to traffic signal installation shall be measured as described herein. Items which are incidental construction required for the installation of a traffic signal will not be measured and will be considered incidental to the work. Construction which is in addition to that required for the installation of a traffic signal shall be measured according to the respective section of these Specifications. Items of equipment and material designated or required for removal will not be measured, and such removals shall be considered incidental to the work. Any other item for installation not measured herein will not be measured and will be considered incidental to the work.

5.01 SIGNAL HEADS.
Accepted signal heads (vehicle and pedestrian) of each size, section, and mounting arrangement specified shall be measured by the individual unit furnished and installed complete in place, per each.

5.02 TRAFFIC SIGNAL CONTROLLERS.
Accepted traffic signal controllers of the type specified shall be measured by the individual traffic signal control unity and cabinet furnished and installed complete in place, per each.

5.03 TRAFFIC DETECTOR AMPLIFIERS.

Accepted vehicle detector amplifiers, including inductive loop vehicle detectors of all sizes and shapes and pedestrian push buttons, shall be measured by the individual unit furnished and installed complete in place, per each.

5.04 TRAFFIC DETECTOR SENSOR UNITS.
Accepted traffic detector sensor units, including inductive loop vehicle detectors of all sizes and shapes and pedestrian push buttons, shall be measured as one complete furnished and installed unit, per each.

5.05 TRAFFIC DETECTOR LEAD WIRE.
Accepted detector lead wire furnished and installed shall be measured to the nearest foot along the saw cut and any conduit between the near loop edge to the outside face of a pull box, pole, or edge of pole foundation (whichever applies). Ten (10) feet will be added to the above measurement for each pull box entry, entry to a pole riser, entry to a pole with the controller cabinet, or entry into a pole (whichever applies). Any conduit will be measured separately.

5.06 SIGN AND SIGNAL SUPPORT POLES.
Accepted sign and signal support poles will be measured by the individual unit furnished and installed complete in place, per each.

5.07 CONDUIT

A. Accepted furnished and field installed rigid conduit shall be measured in linear feet to the nearest foot for each size of conduit installed. Underground conduit will be measured along the conduit by one of the following:

1. From the face of curb to the outside face of a pull box or outside edge of a pole foundation.

2. From the outside face of a pull box to the outside face of a pull box.

3. From the outside face of a pull box to the outside face of a pole foundation or the face of a pole, if the conduit is to be on the outside of the pole.

4. From the outside face of a pole foundation to the outside face of a pole foundation or edge of a pole, if the conduit is to be on the outside of a pole.

B. Above ground conduit will be measured from the ground surface to the underside of a controller cabinet or signal bracket. All other above ground conduit shall be measured as risers.

C. Four (4) feet will be added to the above measurement for each entry to a pull box or pole foundation and each exit of a pull box or pole foundation. For any capped extra entry or exit to a pull box or pole foundation, four (4) feet will be added to the length of conduit measurement. Four (4) feet will be added to the above conduit measurement for each connection between underground conduit and above ground conduit or riser. Three (3) feet will be added to the conduit measurement for any conduit passing through a pull box or foundation without entry or exit.

D. No measurement will be made for conduit in pull boxes, poles, pole foundations, or cabinets except as given above.

E. Accepted jacked conduit will be measured in linear feet from the edge of pavement to edge of pavement under which the conduit is jacked.

F. Accepted field installed conduit risers shall be measured in linear feet to the nearest foot for each size conduit riser installed on the outside of a pole. The measurement will be made along the conduit by one of the following:

1. From the ground to the weatherhead.

2. From the top signal head bracket to the weatherhead.

3. From the bottom of the controller cabinet to the weatherhead.

5.08 PULL BOXES.
Each pull box of the type required will be measured as one complete installed unit, per each.

5.09 CABLES AND CONDUCTORS.

A. The accepted length of cables and conductors of each type and size (number of conductors) installed shall be measured in linear feet to the nearest foot from point to point along the routing for each cable.

B. Horizontal overhead runs of accepted two-conductor power service cable will be measured from face of pole to face of pole. Vertical runs shall be measured from ground surface to the weatherhead for cable both in a pole or in a conduit. No measurement will be made for entries or connections.

C. For accepted signal conductor cable of each size, horizontal measurement will be made by face to face measurement from pole to pole or, when terminating in a signal head, the distance from face of pole to the signal head. Vertical measurement will be made by one of the following:

1. The distance from the ground to the weatherhead (or mast arm).

2. The distance from the bottom of the controller cabinet to the weatherhead (or mast arm).

3. The distance from the bottom of the controller cabinet to the ground.

4. The distance from the ground to the bottom of the signal head or pedestrian push bottom.

5. The distance from the weatherhead (or mast arm) to the top of the signal heads or pedestrian push button.

On both horizontal and vertical runs with two or more cables, each cable will be measured separately. To the above measurement will be added six (6) feet for each entry and for each exit of a signal head; and for each entry into a controller cabinet, eight (8) feet will be added. No measurements will be made of splices required in pole base, condulets, or signal heads and other items which are incidental to the cable.

D. For accepted two-conductor shielded loop lead-in cable installed between the controller cabinet and the loop detector wires, horizontal measurements (overhead or underground) will be made by one of the following:

1. From outside face of pull box to outside face of pull box.

2. From outside face of pull box to the outside face of a pole.

3. From outside face of pole to outside face of pole.

Vertical measurements will be made by one of the following:

1. From the ground to the weatherhead.

2. From the bottom of the controller cabinet to the weatherhead.

3. From the bottom of the controller cabinet to the ground.

On both horizontal and vertical runs with two or more cables, each cable will be measured separately. To the above measurement will be added four (4) feet for each entry and for each exit of a pull box or pole foundation. For entry into the controller cabinet, eight (8) feet will be added. No measurement will be made of splices required in pull boxes or condulets, lashing rods, and other items which are incidental to the cable installation.

5.10 SPAN WIRE ASSEMBLY.
Accepted span wire assemblies shall be measured in linear feet to the nearest foot. The measurement will be from face of pole to face of pole.

5.11 MESSENGER WIRE.
Accepted messenger wire shall be measured in linear feet to the nearest foot. The measurement will be from face of pole to face of pole.

5.12 GUY ASSEMBLY
Guy assemblies of all sizes shall be measured as one complete installed unit, per each.

5.13 SAWCUT IN PAVMENT
Accepted sawcut in pavement shall be measured in linear feet to the nearest foot along the sawcut.

PART 6 – PAYMENT

Payment for accepted work, measured as provided herein, shall be made at appropriate contract unit prices which shall be payment in full for all labor and materials required for a complete and operable installation. Payment shall be made for quantities as shown on the plans unless the work shown on the Plans is changed by the Owner or a field measurement is requested by the Contractor, in which case payment shall be for the approved quantities as changed or for the approved field measured quantities. Payment for all work under this Section shall be made under the pay items listed at the end of this Section.

6.01 SIGNAL HEADS.
Payment will be made for each accepted signal head (vehicle and pedestrian) of each specified size and mounting arrangement at the contract unit price, per each, which will be payment in full for furnishing and installing the signal head including all connection of wiring, testing, and incidental materials for a complete and operable installation.

6.02 TRAFFIC SIGNAL CONTROLLERS.
Payment will be made for each accepted traffic signal controller of the type specified at the contract unit price, per each, which will be payment in full for furnishing and installing the traffic signal control unit and cabinet with connection of power service, signal cable, and detector cable as required to render the signal installation operable.

6.03 TRAFFIC DETECTOR AMPLIFIERS.
Payment will be made for each accepted traffic detector amplifier of the type specified at the contract unit price, per each, which will be payment in full for furnishing and installing the vehicle detector amplifier including mounting and connection to terminals as required to render the signal detection operable.

6.04 TRAFFIC DETECTOR SENSOR UNITS.

A. Payment will be made for each accepted, furnished and installed detector loop wire at field location at the contract unit price for each loop. This shall be payment in full for required saw cut, all turns of the color coded detector loop wire, sealant, and other incidentals required for a complete, tested, and operable installation.

B. Payment will be made for each accepted pedestrian push button with sign at the contract unit price, which will be payment in full for furnishing and installing each push button with sign including banding or other mounting of the sign and push button, wiring, and any necessary materials for a

complete, tested, and operable installation.

6.05 TRAFFIC DETECTOR LOOP LEAD WIRE.

Payment will be made for the accepted length of furnished and installed detector lead wire at the contract unit price, per linear foot. This will be payment in full for required saw cut, twisted wire, sealant, and other incidentals required for a complete, tested, and operable installation. Any conduit and trenching required will be paid for separately.

6.06 SIGN AND SIGNAL SUPPORT POLES.

Payment shall be made for each accepted and installed pole of each length and type at the contract unit price. This will be payment in full for excavation, reinforced concrete, concrete finishing and curing, anchor bolt installation, replacement in kind of sidewalks and pavement, and other incidentals required for complete installation of pole foundations, furnishing and installing the pole (with mast arm, if applicable), plumbing, and other incidentals required for complete installation of the pole ready for attachment of traffic control equipment. The 6 inch deep, 3 foot square concrete top on the foundation is included in the payment for the pole.

6.07 CONDUIT.

A. Payment will be made for the length of accepted and installed conduit, of the sizes and types called for on the Plans, complete with all fittings, couplings, grounding, terminations, banding, and other accessories required for a complete installation at the contract unit price, per linear foot. Payment will include excavation and backfilling of all trenches, including surfacing with sod or other material as removed. Payment will include removal and in kind replacement of curb, curb and gutter, sidewalk, driveway, and portland cement concrete and asphaltic concrete pavement.

B. Payment will be made for the accepted length of jacked conduit at the contract unit price for each size of jacked conduit. This will be payment in full for all labor, excavation, backfilling, conduit, and other incidentals required for complete installation.

C. Payment will be made for the length of accepted and installed rigid conduit riser of the sizes called for in the Plans at the contract unit price for each size of rigid conduit riser. This will be payment in full for required fittings, bushing, condulets, banding, clamps, and accessories necessary for complete installation and grounding at all conduit riser locations.

6.08 PULL BOXES.

Payment will be made for each accepted pull box at the contract unit price for each type pull box installed as a complete unit. This shall be payment in full for excavation, including removal of sidewalks and pavement, installing the unit as detailed in the Plans, backfilling as required, crushed stone base, replacement in kind of sidewalks and pavement, and other incidental items required for the complete installation of the pull box.

6.09 CABLES AND CONDUCTORS.

A. Payment will be made for the accepted length of two-conductor power service cable at the contract unit price for the cable type and size. This will be payment in full for the required splicing and termination in the cabinet, cable pulling, lashing, and other incidentals for complete installation. When power service is provided in the controller cabinet by others, no payment will be made to the Contractor for power service cable.

B. Payment will be made for the accepted length of signal conductor cable of each size installed at the contract unit price. This shall be payment in full for all terminations, splices, cable pulling, lashing, and other incidentals required for installation and hookup.

C. Payment will be made for the accepted length of two-conductor shielded loop lead-in cable installed in the field location at the contract unit price for the cable. This will be payment in full for splicing, pulling, lashing, and other incidentals required for a complete installation.

6.10 SPAN WIRE ASSEMBLY.
Payment will be made for the accepted length of installed span wire assembly at the contract unit price. This shall be payment in full for required span wire, tether wire, clamps, pole attachments, and other incidentals required for a complete installation.

6.11 MESSENGER WIRE.
Payment will be made for the accepted length of installed messenger wire at the contract unit price. This shall be payment in full for pole attachments and other installation incidentals required.

6.12 GUY ASSEMBLY.
Payment will be made for each accepted and installed guy assembly at the contract unit price. This shall be payment in full for all guy wire, attachment hardware, anchors, and other installation incidentals required.

6.13 SAWCUT IN PAVEMENT.
Payment will be made for the accepted length of sawcut in pavement at the contract unit price. This pay item shall not include sawcut for traffic detector sensor units or detector loop lead wire, for which payment shall be made as described in Paragraphs 6.04 and 6.05 of this Specification Section; this pay item shall include sawcut in pavement of any other purpose. Payment shall not include detector cable, or any other cable or wires, for which payment shall be separate. This will be payment in full for required sawcut, sealant, and other construction incidentals required.

6.14 PAYMENT WILL BE MADE UNDER:

PAY ITEMS

Item Number	Description	Pay Unit
02890-01	SIGNAL HEADS	Each
02890-01.01.__.__	Vehicle Signal Head Number of Arrow Lenses Number of Optically Programmed Lenses Number of 12” Lenses Number of 8” Lenses	Each
02890-01.02.08.00	Pedestrian Signal Head (8” Lenses)	Each
02890-01.02.12.00	Pedestrian Signal Head (12” Lenses)	Each
02890-01.02.12.10	Pedestrian Signal Head (12” Lenses, Optically Programmed)	Each
02890-02.__	TRAFFIC SIGNAL CONTROLLERS Number of Phases	Each
02890-03	TRAFFIC DETECTOR AMPLIFIERS	Each
	Inductive Loop Vehicle Detector Amplifier	Each
02890-04	TRAFFIC DETECTOR SENSOR UNITS	Each
02890-04.01	Inductive Loop Vehicle Detectors	Each
02890-04.02	Pedestrian Push Buttons	Each
02890-05	TRAFFIC DETECTRO LOOP LEAD WIRE (TWISTED)	Lin. Ft.
02890-06	SIGN AND SIGNAL SUPPORT POLES	Each
02890-06.01.__.__	Steel Strain Poles Pole Length (Feet) Anchor Base Size (Inches)	Each
02890-06.02.__.__	Mast Arm Supports Mast Arm Length (Feet) Anchor Base Size (Inches)	Each

02890-06.03	Pedestal Poles	Each
02890-06.04.__.__	Wood Poles Length (Feet) Class	Each
02890-07	CONDUIT	Lin. Ft.
02890-07.01.__.__	Trenched Underground Conduit Depth (Inches) Size (Tenths of Inches)	Lin. Ft.
02890-07.02.__	Jacked Conduit Size (Tenths of Inches)	Lin. Ft.
02890-07.03.__	Conduit Riser Size (Tenths of Inches)	Lin. Ft.
02890-08	PULL BOX	Each
02890-08.01	Type “A” Pull Box	Each
02890-08.02	Type “B” Pull Box	Each
02890-09	CABLES AND CONDUCTORS	
02890-09.01	Two-Conductor Power Service Cable	Lin. Ft.
02890-09.02.__	Signal Conductor Cable Number of Conductors	Lin. Ft.
02890-09.03	Two-Conductor Shielded Detector Cable	Lin. Ft.
02890-10	SPAN WIRE ASSEMBLY	Lin. Ft.
02890-11	MESSENGER WIRE	Lin. Ft.
02890-12	GUY ASSEMBLY	Each
02890-13	SAWCUT IN PAVEMENT	Lin. Ft.

END OF SECTION 02890